DEVELOPMENT OF AN INTERFACE-UNIT BETWEEN AN AUDIO TAPE AND A DIGITAL TAPE, AND THE ASSOCIATED SOFTWARE

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CERTIFICATE

This is to certify that this work has been carried out under my supervision and it has not been submitted elsewhere for a degree.

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ABSTRACT

Feasibility study of a replacement for card-storage using audio tape was carried out by A.V. Krishnakumar and Satishchandra.[1,2] The whole system consists of three units, viz., the input unit, the interface unit and the software packages for editing and file-verification. The input unit has a non-printing type keyboard. Data is stored on a single track audio tape in the form of 6 bit computer compatible code. Interface unit reads the information from the audio tape and puts on a seven track digital tape after adding the parity bit.

Laboratory model of interface unit has been designed and fabricated. Required power supplies with short-circuit protection have also been made. Software packages for editing and file-verification have been written in the assembly language of IBM 1620.

CHAPTER 1

1.1 INTRODUCTION

Communication with a data-processing system is through an input-output (I/O) device. Data to be processed and the instructions for processing it are first recorded on an input-medium such as punched cards, punched paper tape, magnetic tape, magnetic ink characters or optical characters.

The computer is capable of operating at much faster speeds than an I/O device. To enable the computer to operate as nearly as possible at its full capacity, the transfer of data between I/O devices and the main storage unit may take place independently through an intermediary.

Off-line input-output devices are frequently used on large systems. Information recorded on an input device is transferred onto an auxiliary storage unit which can directly be connected to the computer for information transfer under control of CPU. This improves computer-utility as the information from an auxiliary storage unit viz., magnetic tape, disk or drum can be read at a faster rate (tens of thousands of characters per second).

The off-line system should be economic and reliable. Feasibility of the sound recording tape as an off-line input

device was studied by A.V. Krishnakumar and Satish Chandra[1,2]. It was found feasible and can compete well with punched cards and punched paper tapes and it has the following advantages:

1. Ecocomy: Such a recording tape can be used over and over again unlike punched cards and punched paper tape.

2. Higher Information Packing Density: On an average one card image per square inch in this case as against 8 square inches in case of punched paper tape and about 20 square inches in case of a punched card.

3. More Reliable System: This input unit is mostly electronic as against card punch and paper tape punch which are mainly electromechanical devices. Hence this is more reliable system and requires very little maintenance.

4. Variable-Data-Length: Unlike card, there is no restriction on the number of characters in a record. Continuous string of data can be stored.

5. No Need of Code-Conversion: Card-code and paper-tape are different from the magnetic tape-code, which gives rise to having a subsystem for code-conversion. The subsystem for code-conversion is not required in this case as the information can be recorded in the same code as that of magnetic tape.

6. Cheaper: The input unit works out to be cheaper than the existing card punch and the paper tape punch. Expected cost is about Rs. 6,000/-.

However this system has the following disadvantages:

(a) Magnetic tape is more sensitive to dust-particles, humidity and temperature. Installation of such units requires construction of a dust-proof room with airconditioning and humidity controls. Dust particles on the surface of the tape cause non-uniformity of the distance between the tape surface and the Read/Write head. This would result in drop-outs.

(b) Human updating is not possible because the recorded information on the magnetic tape is invisible to human eye, whereas with punched cards, it is easy to pick out the desired card and examine it.

(c) Sequential-processing: It is not possible to have access to a record in a file without passing all the tape upto the point where the desired record is stored.

However in some applications advantages far weigh the disadvantages as in the case of:

(i) commercial data processing; and

(ii) operating data from chemical process where certain parameters are recorded continuously (sampled over certain time-interval).

This may not be useful in educational institutions where beginners want to examine the recorded information. A beginner will prefer the punched card. If the display of 80 character-information is associated with this input device, the cost will increase. In case of commercial data processing this

display is not required. Expert operators don't wait and examine the recorded information while recording. Verification of the recorded information is accomplished separately.

1.2 OBJECTIVE OF THE PROJECT

In a previous project[1,2] a feasibility study for storing digital information on an audio-tape recorder was conducted. The objective of this project is to receive the information from the audio tape and store it on a digital magnetic tape ready for input to a computer. In the process of preparing the digital tape problems of verifying and of editing data have been investigated. The entire system thus consists of the following units:

1. Input unit comprising a key-board and an audio-tape unit with necessary control logic.[1,2]

2. Interface unit to transfer the content of the audio-tape to computer compatible digital tape.

3. Developments of EDIT and file-verification programs for editing and verifying the generated data-files.

Auxiliary unit with the system is power-supply unit comprising four fixed voltage regulating circuits for -27 volt, -13 volt, +13 volt,&+ 3.6 volt.

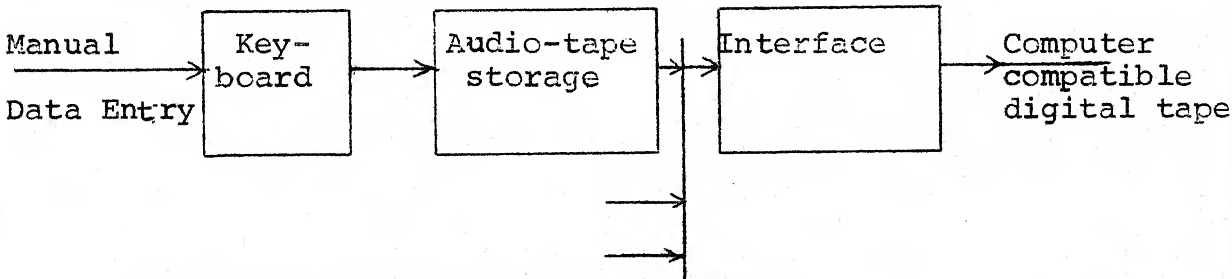


Figure 1.1: System Block Diagram

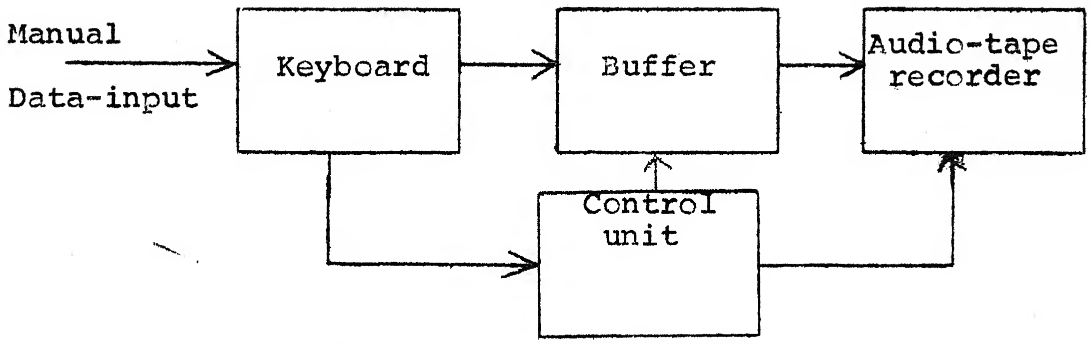


Figure 1.2: UNIT-1

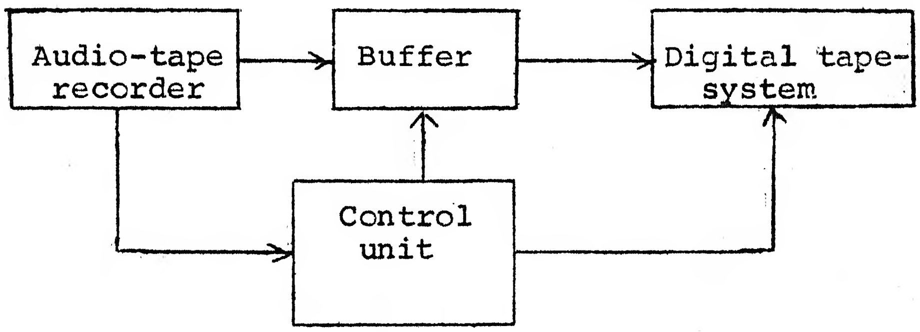


Figure 1.3: UNIT-2

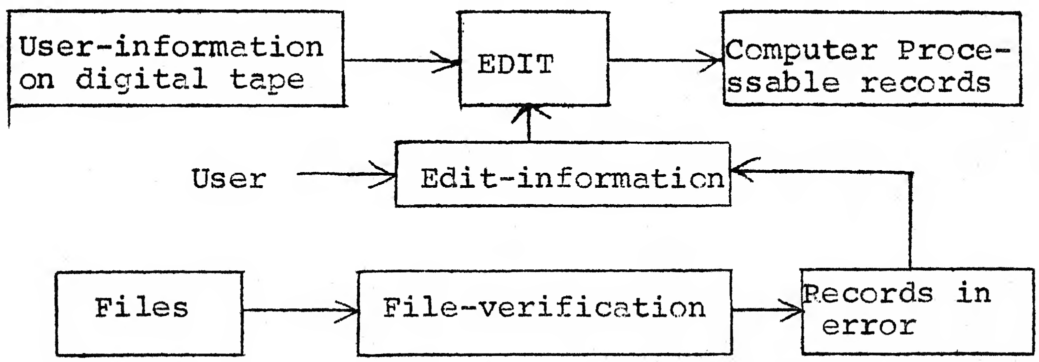


Figure 1.4: UNIT-3

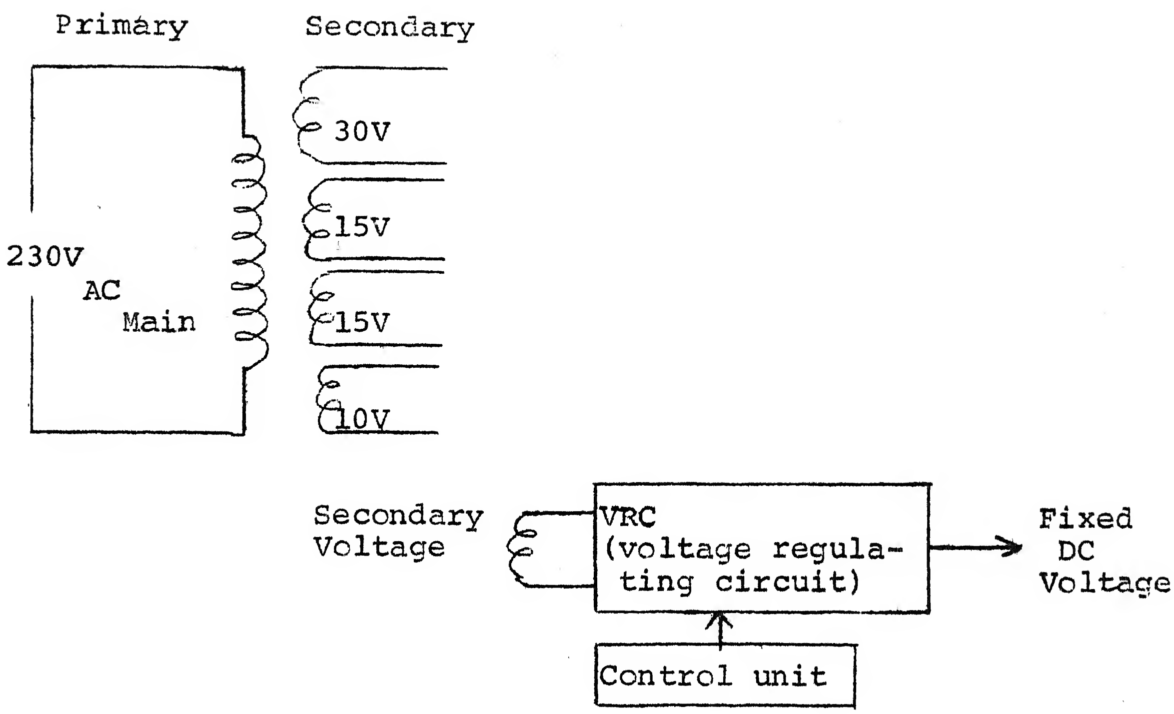


Figure 1.5: UNIT-4

1.3 HARDWARE-SPECIFICATIONS

As the previous audio tape unit was not available in working order at the time the project was undertaken it was decided to simulate the output of the audio tape recorder by means of a programmable pulse generator. The proposal [1,2] was to run the audio-tape at a speed of 15 inches/second which would give output pulses with pulse-duration of 0.5 m sec and frequency 2KHz. This has been taken as the input to the interface unit. The output of the interface unit is a series of pulses in NRZ(I) form which is compatible for recording on a seven track IBM tape with 200/556 bpi and speed of 36 inches/second.

1.4 SOFTWARE SPECIFICATIONS

In case of punched cards editing is easy as cards may be readily inserted or deleted. Punched paper tape does not have this flexibility but it can be spliced to add new tape. In the case of audio tape, editing is very difficult as invisible data is stored serially on magnetic tape which cannot be spliced at the exact place where new information is required. Thus the information recorded on audio tape includes a serial number with each record on the tape.[1,2] Editing information to be edited is given at the end of the file.

Drop-out of bits is encountered while recording on an audio-tape. This is overcome by storing a relatively higher frequency sinewave pattern, e.g. 2KHz while recording tape speed is 15/8" / sec. Whenever a record is mutilated and such drop-out is detected on play-back at the end of the record, this incorrect record is to be discarded.

1.4.1 EDIT and FILE-verification

Edit program has been developed to edit the recorded files. Its functions are to:

(a) ADD a number of records after the specified serial number.

(b) MODIFY a record

(c) DELETE a number of records as required

(d) STRAIGHT COPY the file, without any editing, after blanking the last four columns used for serial number in a record.

A file verification program has been developed to compare records from two tapes digit by digit. Mismatch-location is indicated. Records found in error are printed or punched out depending on the write-instruction. Assuming the probability that a well trained keyboard operator commits an error in keying is quite low, the probability of two operators commi-tting identical errors is still quite low. We can thus safely assume that wrong files are being compared or a record is missing in case more than four mismatches occur in consecutive records. This file-verification program skips the current file whenever more than four mismatches are found in two adjacent records.

CHAPTER 2

REVIEW OF AN AUDIO TAPE STORAGE FOR DIGITALLY CODED ALPHANUMERIC DATA - A FEASIBILITY STUDY

Unit-Specifications:

1. Key board comprising 48 keys

2. Encoding matrix associates each key with a set of 6 bits which are stored in a 6x80 bit-buffer. Buffer content is written onto a steadily running audio-tape at 250 Hz.

3. There is provision to modify the content of the buffer.

4. IBM tape-codes are used [Appendix 1).

5. Last four characters of a 80-character-record are reserved for serial number, trailing-end blanks are filled upto 76th position.

6. Information is recorded at 250 Hz after the tape picks up its steady speed - 15/8"/sec. Tape recorder is equipped with a read head, a write head and an erase head. There is only one track for recording the information.

7. Drop-outs are detected by echo-checking technique in which recorded character is read back and compared with the character which should have been written. In case of discrepancy, 2KHz sinewave pattern is recorded for 0.5 sec at the end of the record.

8. NRZ recording technique is applied alongwith the clock information by using the teletype start-stop code.

Specifications of the output from the audio-tape, which is used as input to the Interface-Unit are the following:

Output voltage is about 10 mV. Recorded waveforms are illustrated in Figure 2.1

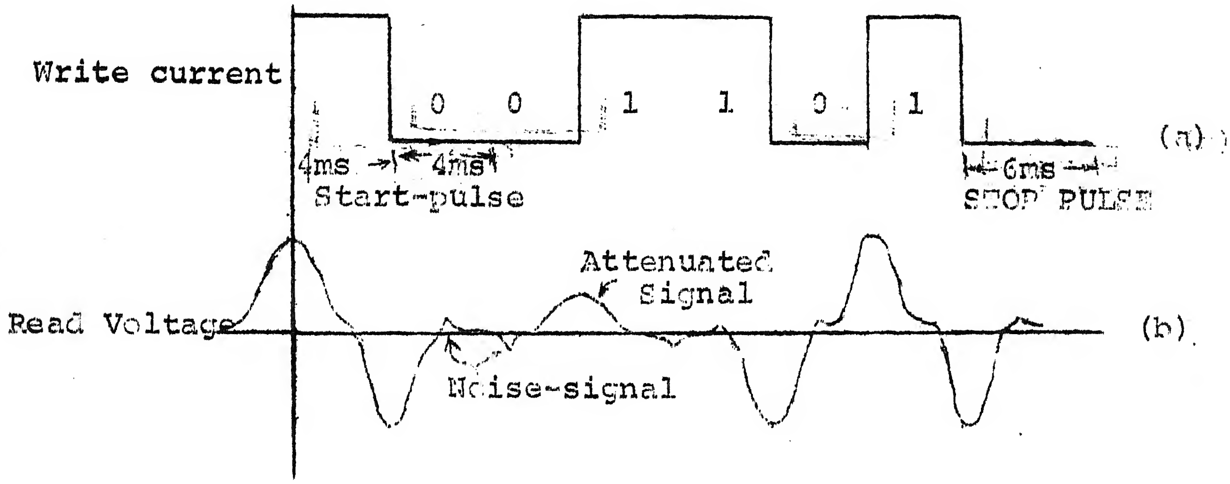


Figure 2.1: Recording of a character - 001101.

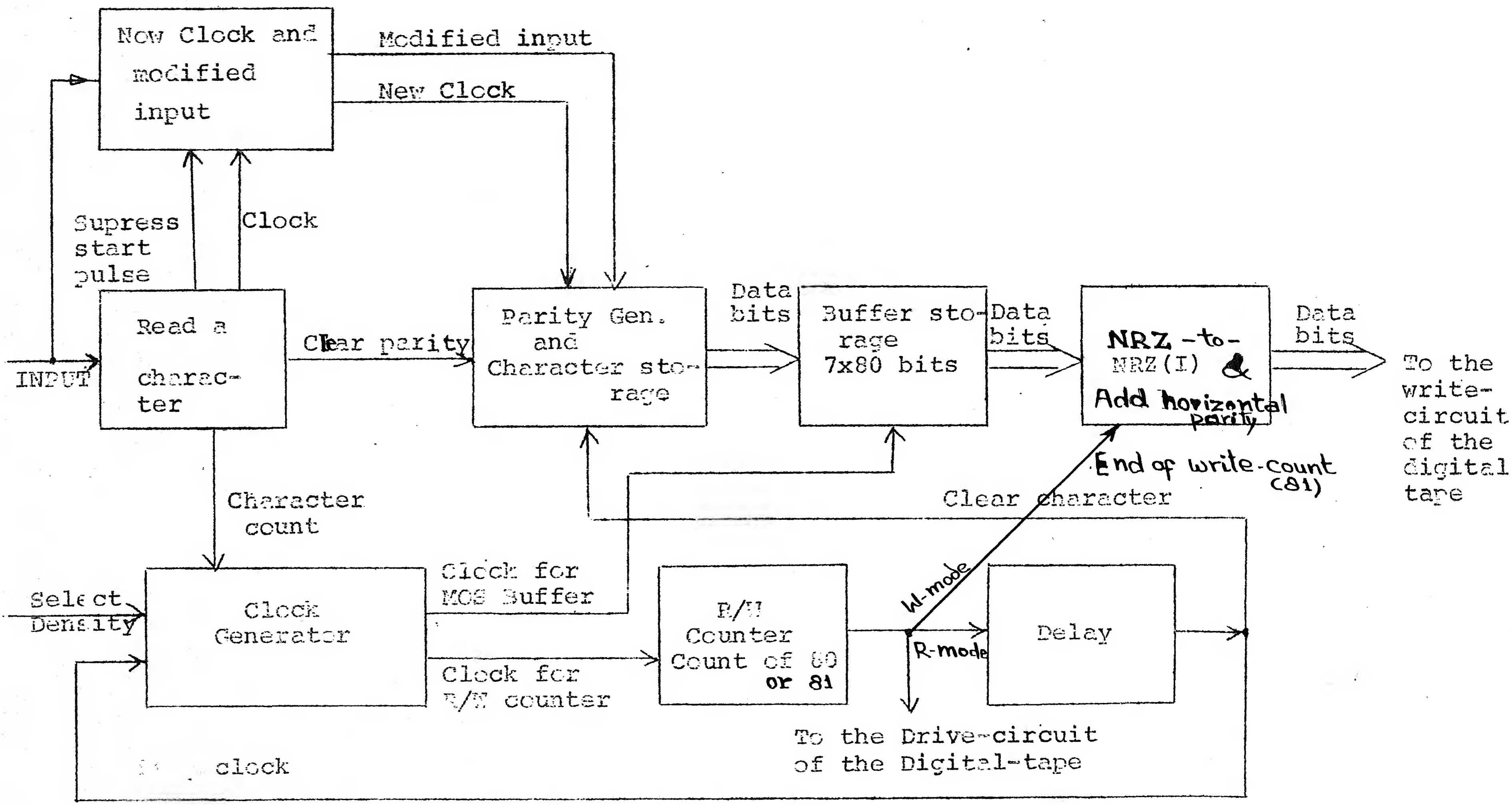


Figure 3.0: Block diagram of the Interface Unit

CHAPTER 3

INTERFACE-UNIT

3.1 INTRODUCTION

The signal obtained from the audio tape head is detected by means of peak sensing technique. During reading, provision is to be made to detect drop-outs. Thus the method indicated in Figure 3.1 can be used.

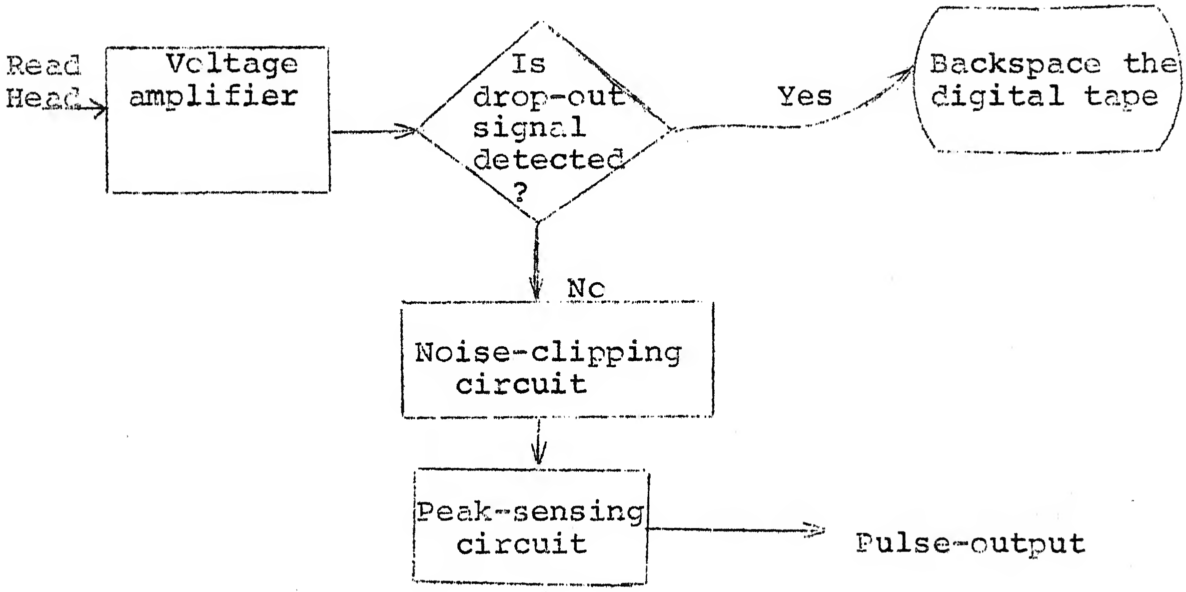


Figure 3.1: Read the audio-tape content

NRZ waveform can be obtained from output pulse-train by means of the following method. This waveform is the replica of the recording-current.

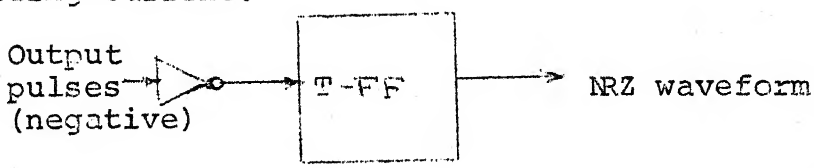


Figure 3.2

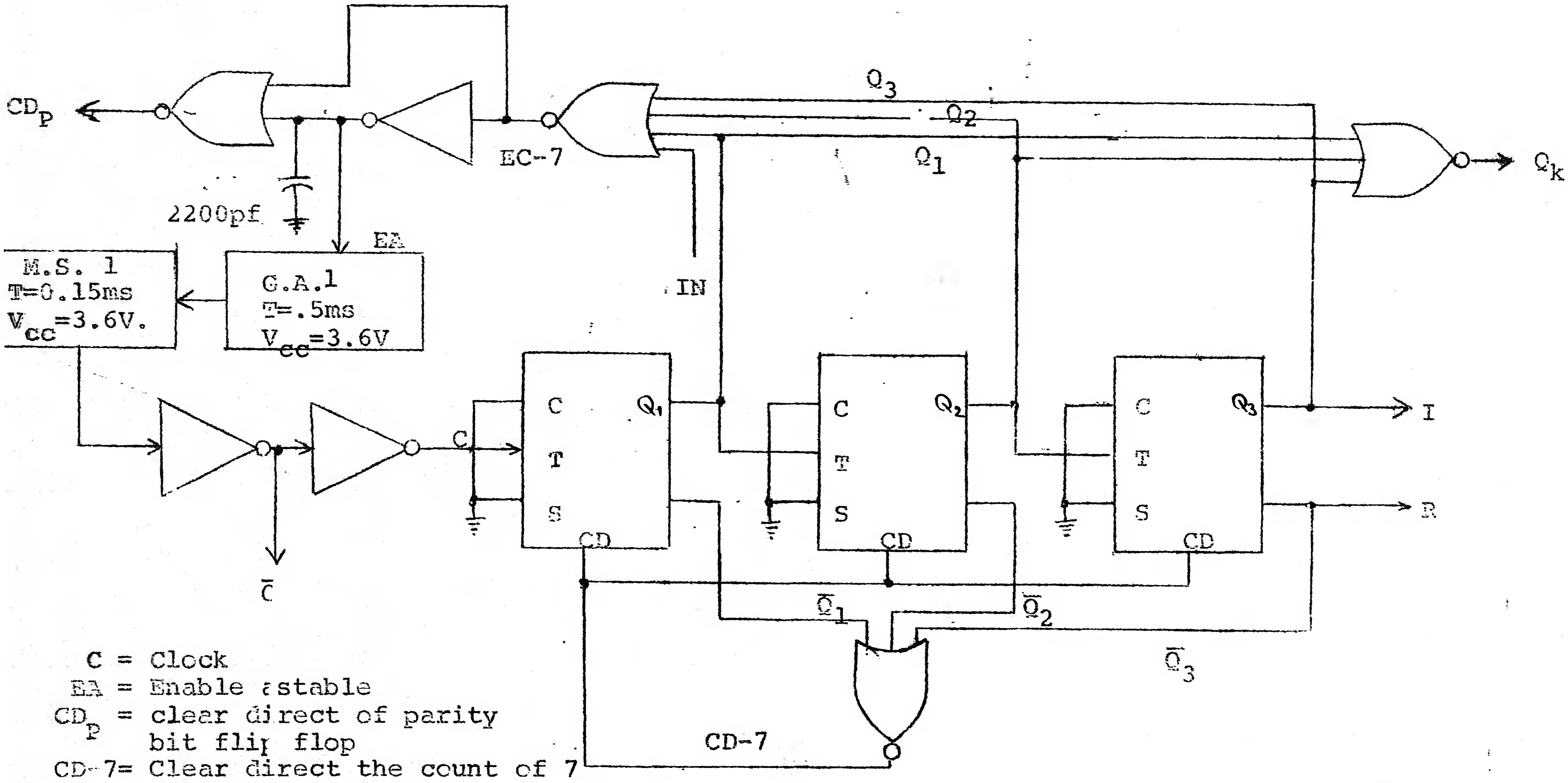
Figure 3.2: INPUT in NR Z form

3.2 READ A CHARACTER

Input to the interface unit is a pulse-train in NRZ recording as shown in Figure 2.1(a). When a new character is recorded a start-pulse precedes the coded character which is followed by a stop pulse whose width is 1-1/2 times the width of the coding pulse.

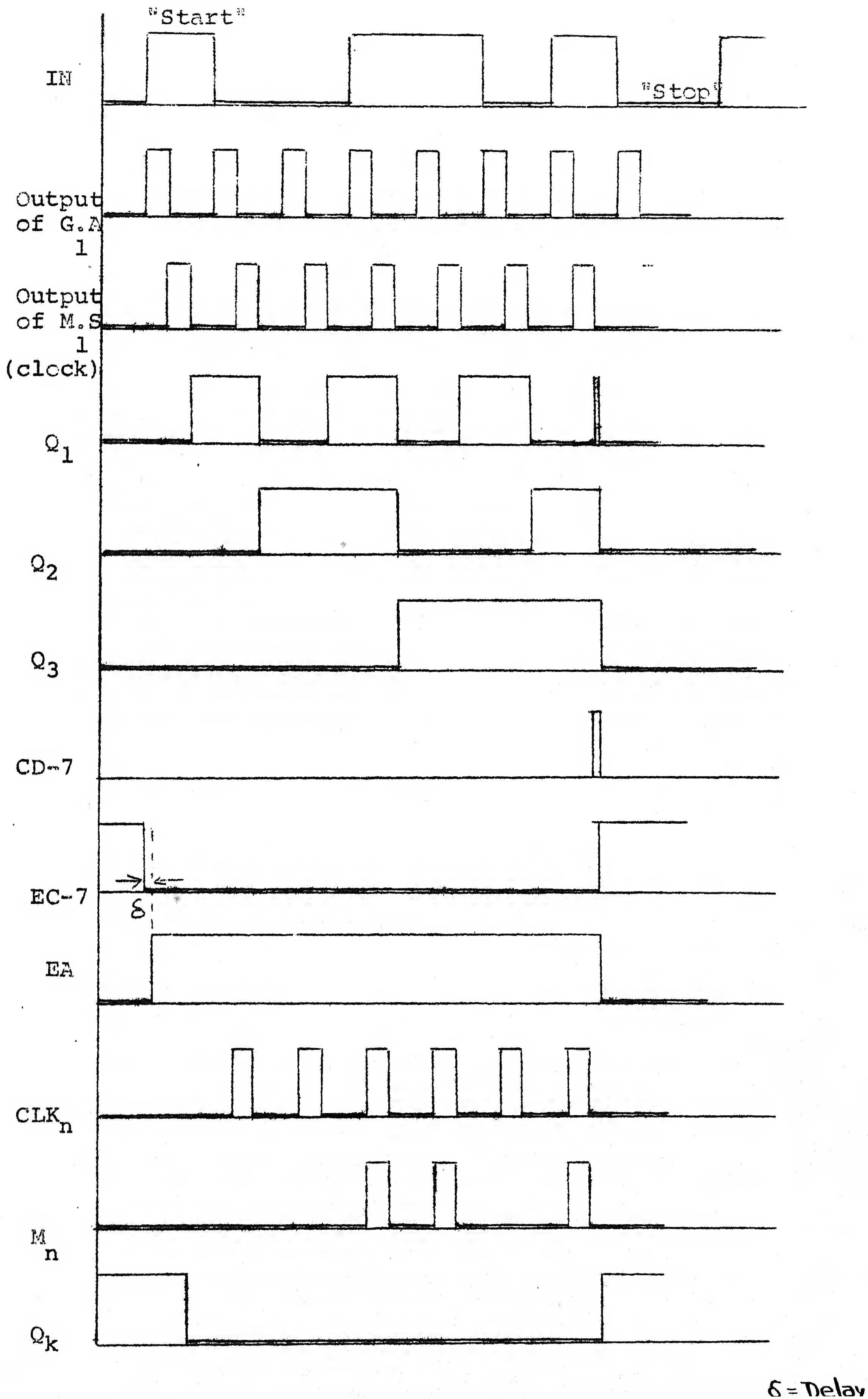
The circuit to generate clocks when a new character is read is given in Figure 3.3.

Start of a character changes the voltage level to logical '1'. In the beginning all the flip flops are cleared. So long as IN (Input) is at '0' level, EC-7 is '1' and EA is '0' and the gated astable is disabled. As IN goes to '1' level, EA becomes '1' and gated astable GA 1 is enabled to give clock of period 0.5 ms. This clock is fed to the count of 7 which assures atleast one of Q_1, Q_2, Q_3 is '1'. So, EA is '1' till 7^{th} pulse. 8^{th} pulse is a stop-pulse at '0' level. After 7 pulses, counter is cleared and all of Q_1, Q_2, Q_3 are '0', IN is also '0', hence EA goes down to '0' level, which disables the gated-astable M.S. 1 is triggerred at the negative going edge of the G.A. 1 output pulse. This is the clock used in subsequent operations. This is repeated when another (positive going) [redacted]-start pulse occurs.



C = Clock
EA = Enable astable
CD_P = clear direct of parity bit flip flop
CD-7= Clear direct the count of 7

Figure 3.3: READ A CHARACTER


"Start"
"Stop"
IN
Output of G.A 1
Output of M.S 1 (clock)
Q1
Q2
Q3
CD-7
EC-7
δ
EA
CLKn
Mn
Qk
δ = Delay

Negative transitions at Q_3 from '1' to '0' are counted by a Read/Write counter which functions as a count of 80 during read-mode and as a count of 81 during write-mode.

Check-bit flip flop of the parity generator should be cleared before the next character starts. At the negative transition of EC7 which corresponds to the start of a new character, edger gives out a short pulse to clear-direct the check-bit flip-flop to make it ready for generating the parity-bit for the next character.

Timing diagrams are shown in Figure 3.4.

Overall frequency change while reproducing is about ± 4%. Deviation of the occurrance of the last pulse from its correct occurrence time will be

$$= 7 * 0.5 * .04 \text{ msec}$$

$$= .14 \text{ msec.}$$

Clock lies in the middle of the pulse duration to assure the reading of the bit pulse.

3.3 NEW CLOCK AND NEW MODIFIED INPUT

To generate the parity bit, a pulse is required for each occurrance of '1'. This is obtained by ANDing IN with clock. Clock and this modified input have a positive pulse corresponding to the start pulse which is to be suppressed. Method to generate new clock and new modified input is illustrated

in Figure 3.5. Timing diagram for CLK_n (new clock) and M_n (new modified input is shown in Figure 3.4.

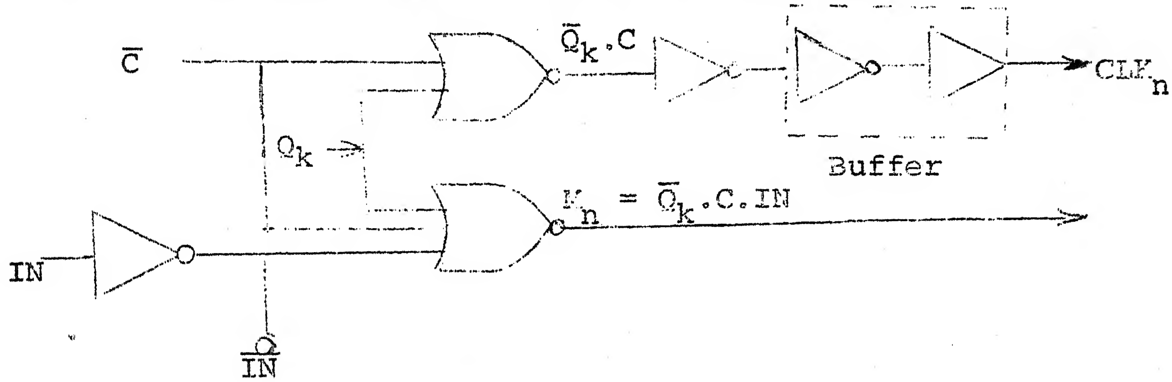


Figure 3.5: New Clock & New Modified input

3.4 PARITY-GENERATOR AND STORAGE FOR A CHARACTER

As illustrated in Figure 3.6, M_n toggles the check-bit flip flop whose output is '1' for odd number of 1's and '0' for even number of 1's in the character just read from audio-tape. Bits following the start pulse are shifted in the 6-bit shift register. Thus we get 7 bits for a character which are ready to be transferred in parallel into the buffer. But buffer-input logic level is different from that of the flip-flops in the parity generator, so a level shifting network is required.

3.5 GENERATION OF CLOCK FOR MOS BUFFER

Two clocks are required to transfer the data into the MOS-buffer and shift the data internally. Figure 3.7 illustrates the generation of such clocks ϕ_1 and ϕ_2 during READ and WRITE mode. M.S.-3 and M.S.-4 are two monostables which

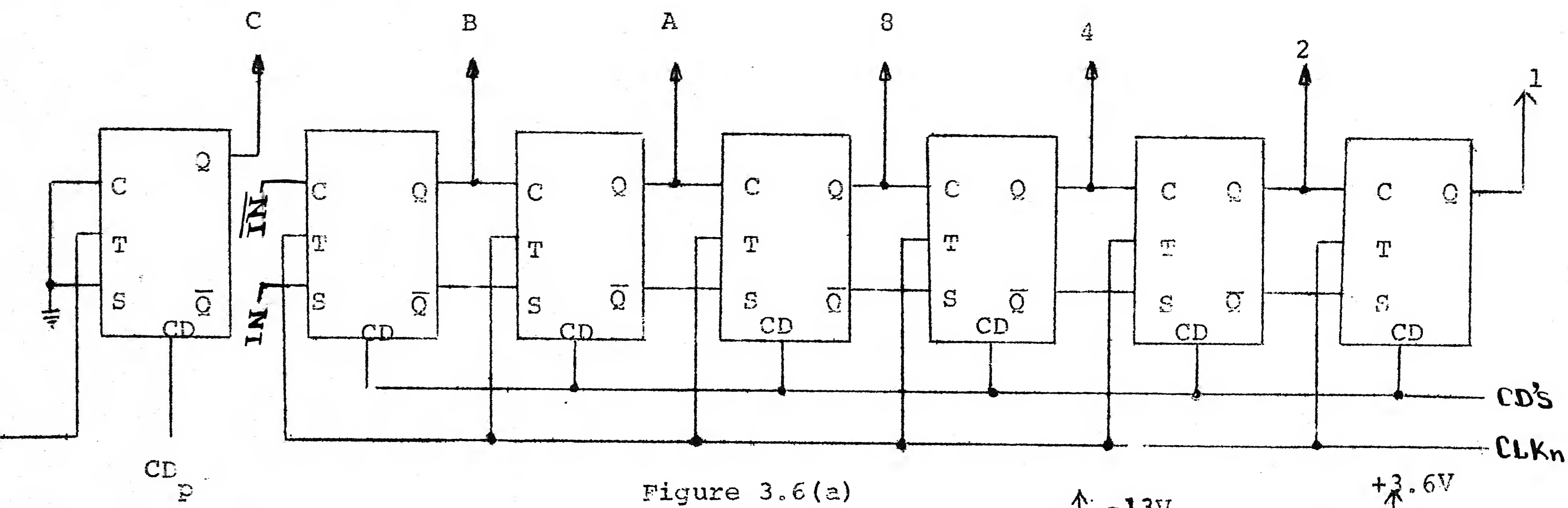


Figure 3.6(a)

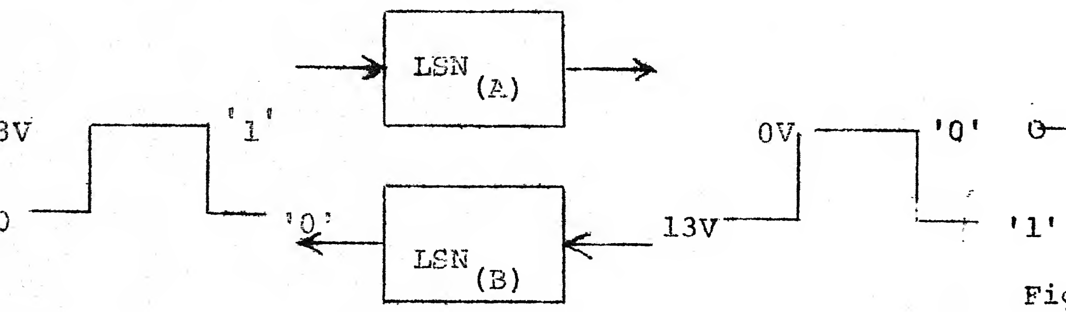


Figure 3.6(b)

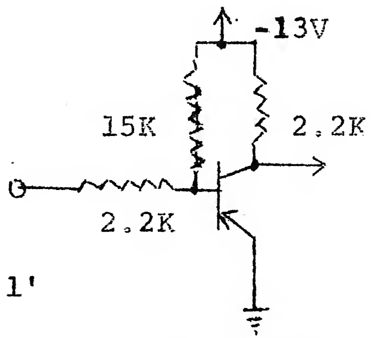


Figure 3.6(c): $LSN_{(A)}$

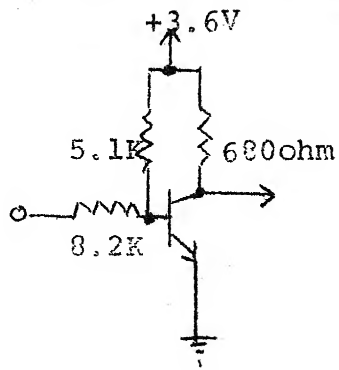


Figure 3.6(d): $LSN_{(B)}$

Figure 3.6: Parity Generator and Storage for A Character

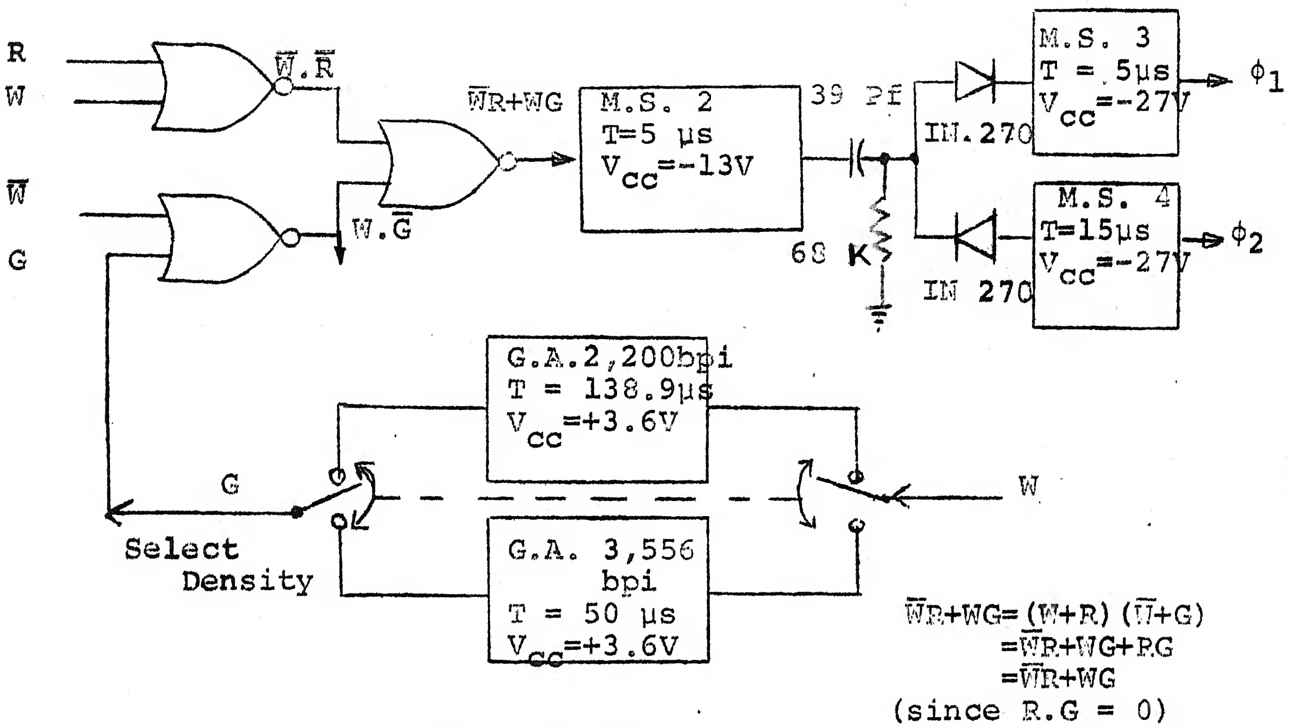
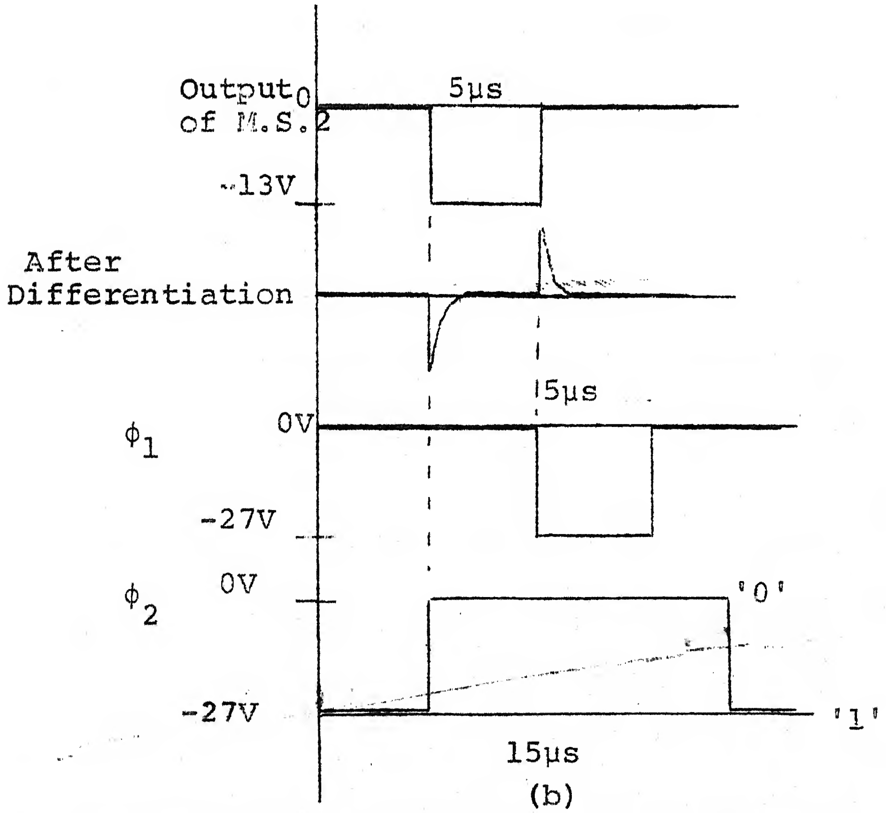


Figure 3.7(a)



(b)

Figure 3.7(a): Generation of the clocks ϕ_1 and ϕ_2
(b): Timing Diagram

are
triggered at the positive and negative going edge of the pulse output of M.S. 2.

During read-mode ($\overline{W}$=1), a character is to be transferred after adding the check-bit. Hence M.S. 2 is triggered when R($\overline{Q}_3$) of count of 7 rises from '0' to '1'. In case of write-mode, buffer-content is transferred to write-heads at the faster rate than the transfer-rate during read-mode. G.A. 2/G.A. 3 produces a train of 81 pulses which are used to trigger M.S. 2 and then M.S. 3 and M.S. 4. G.A. 2/3 is enabled when W=1. Information packing density on digital magnetic tape is selected by SELECT-DENSITY-Switch which enables the desired G.A. It takes 16.2 msecs to transfer the buffer-content onto digital magnetic tape at low density, while inter-record-gap is about 62.5 ms. Thus R and G will never occur simultaneously.

3.6 READ/WRITE COUNTER

80 characters are to be stored during READ-mode. In write mode, a horizontal parity is also added after transferring 80 characters. Figure 3.8 illustrates a counter to count 80 in read-mode and 81 in write-mode. Horizontal parity is added by clearing-direct the write-head flip-flop.

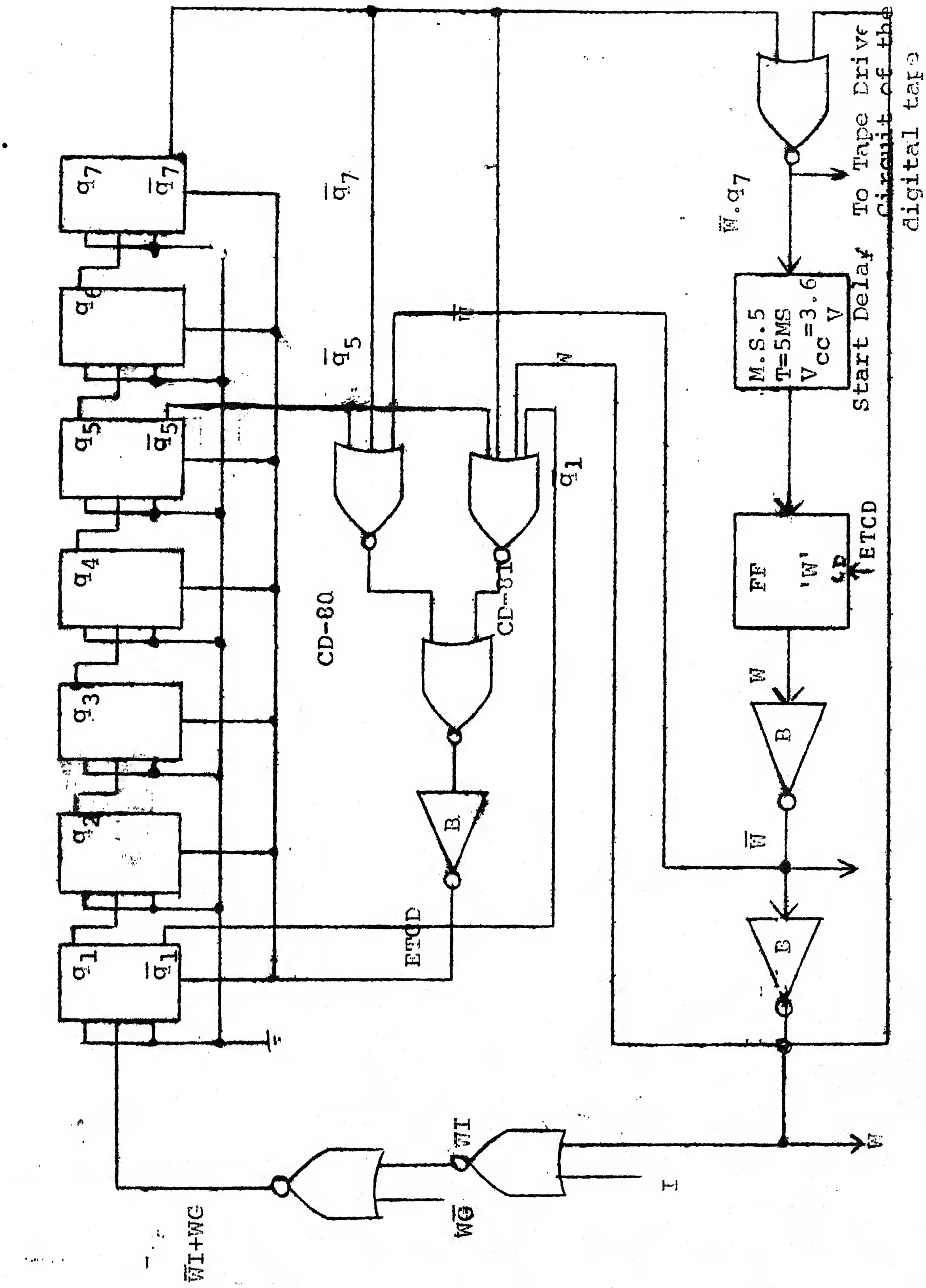


Figure 3.8: READ/WRITE counter

State 0000101 represents 80, whereas 1000101 represents 81. Negative going transition can be used in READ-mode only to enable the tape drive circuit. Digital tape takes about 5 milliseconds to pick up the steady speed. M.S. 5 is triggerred to introduce a delay of 5 milliseconds. Flip flop 'w' is toggled after 5 milliseconds to make w=1. This will enable the G.A. 2 or 3 to produce 81 count pulses. Signal to tape drive circuit and to M.S.5 is to be inhibited during write mode. Flip flop 'w' is cleared whenever count of 80 or 81 is over.

3.7 BUFFER STORAGE

A buffer is required because of the speed mismatch between the output of the audio tape and the input requirement of digital tape.

TMS-1B, 3016-LA, dual-16 bit static shift register is used for this purpose. Details about the shift register are given in Appendix 4.

3.8 NRZ(I)

Information on an IBM digital magnetic tape is recorded in NRZ(I) form. Every transition of an NRZ(I) waveform corresponds to '1'-bit of a character. By ANDing the buffer output with ϕ_2, we can get a pulse for every '1' bit. Such

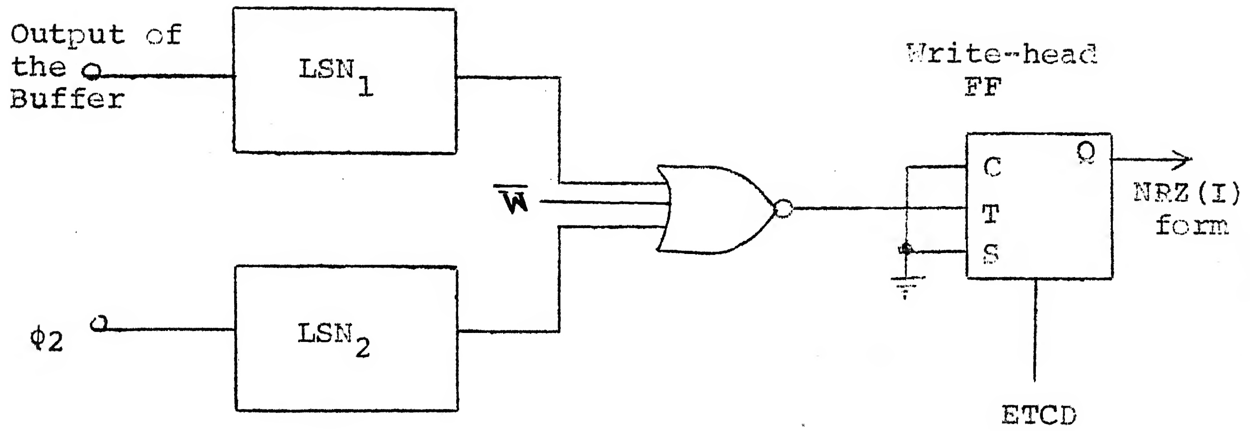


Figure 3.9(a)

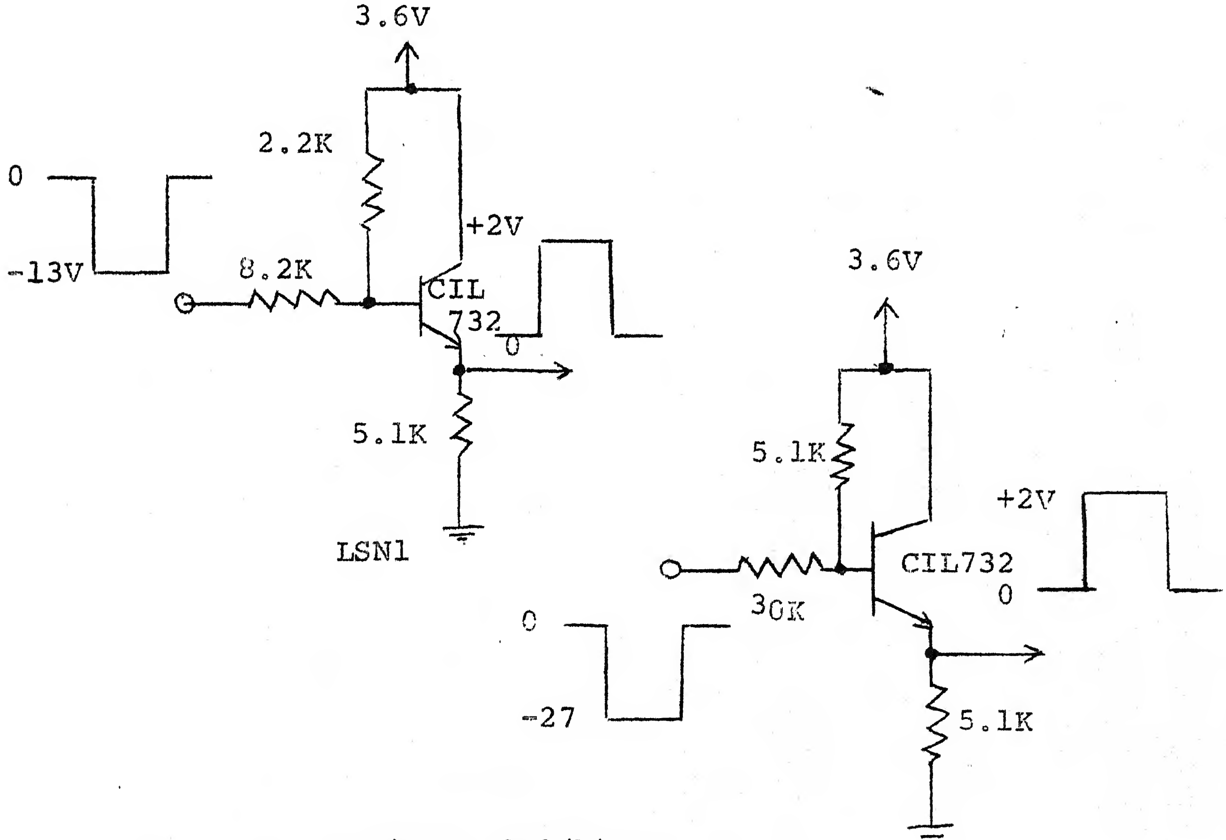


Figure 3.9(b)

LSN2

Figure 3.9(a): Block diagram to obtain NRZ(I) form
(b): Circuit details

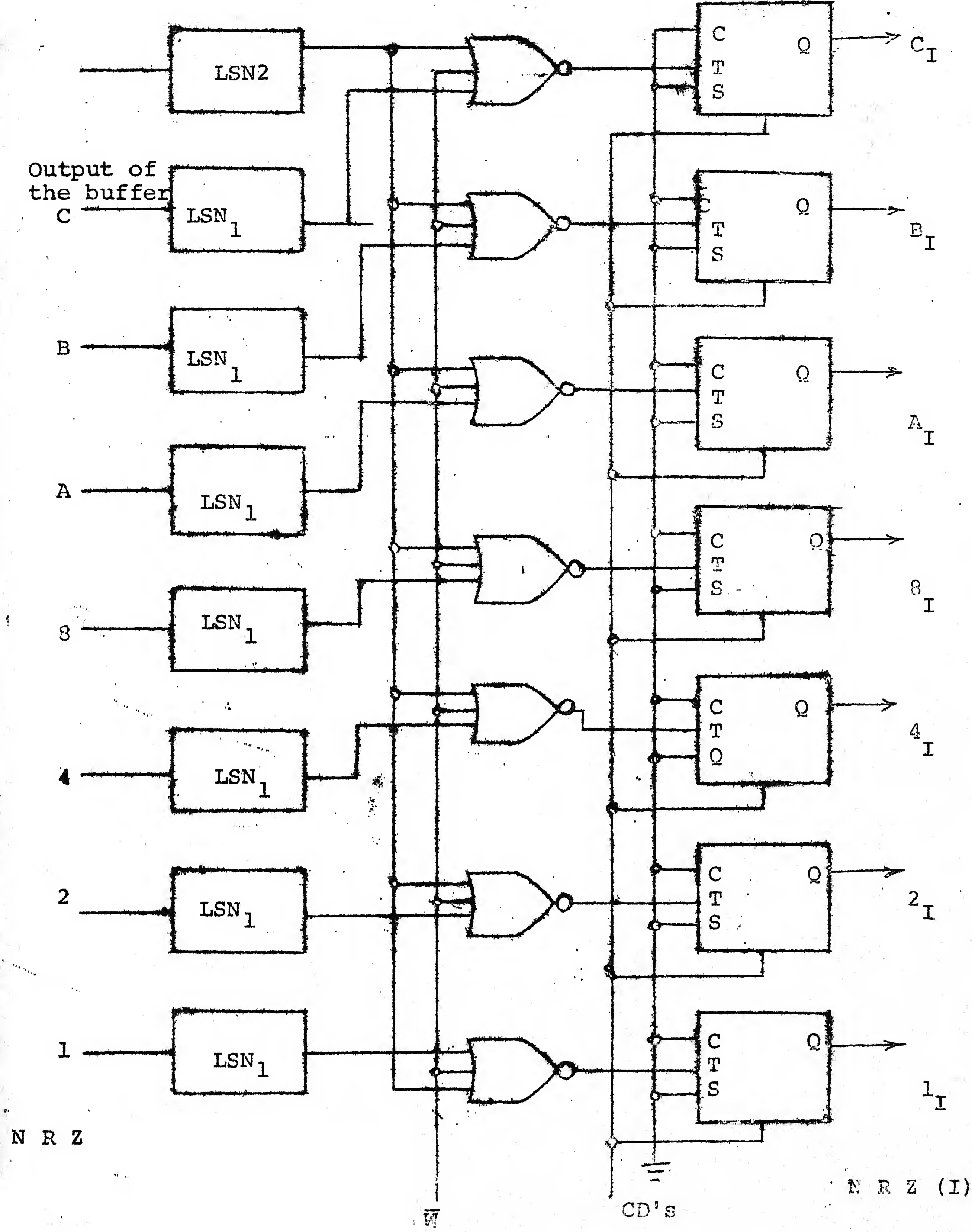


Figure 3.9(c). Block diagram to obtain NRZ(I) form from the NRZ output of the buffer.

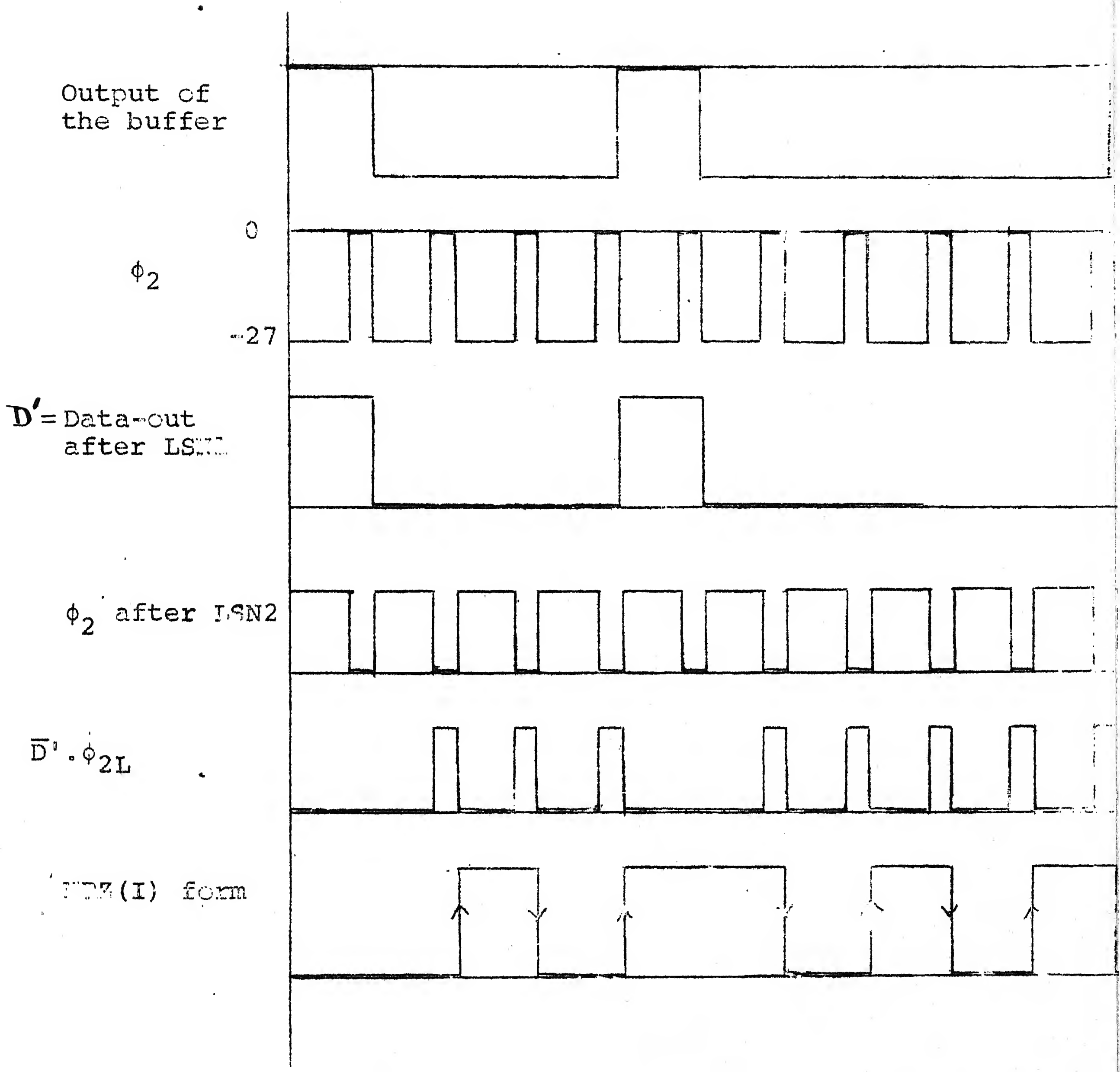


Figure 3.9(c): Timing diagram for ϕ_2, data-out and NRZ(I)

a pulse-train is used to toggle the write-head flip flops as to obtain the NRZ(I) pattern.

Information on tape:

Vertical parity bit

81st character

C	0	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	X
B	1	0	1	.	.	.	.	.	.	.	.	.	.	.	.	.	X
A	0	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	X
8	1	0	0	.	.	.	.	.	.	.	.	.	.	.	.	.	X
4	1	1	0	.	.	.	.	.	.	.	.	.	.	.	.	.	X
2	0	0	0	.	.	.	.	.	.	.	.	.	.	.	.	.	X
1	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	X

$$X = \begin{cases} 1, & \text{if number of 1's in the row is odd} \\ 0, & \text{if number of 1's in the row is even.} \end{cases}$$

81st character consists of horizontal parity bits.

CHAPTER 4

EDIT and FILE-VERIFICATION

4.1 Software programs are developed to edit files and to verify the data in a file. These programs have been written in SPS language and tested on IBM 1620 at the Computer Centre, Indian Institute of Technology, Kanpur.

Before we proceed further, we define a few terms:

File-reel: digital tape-reel from which information is read.

Take-up reel: digital tape-reel on which information is to be written.

Command-record: an instruction record in the edit-file.

Program-record: consists of two sets of characters-first set of 76 character-information and second set of last four character-serial number which is used to facilitate the editing of a file.

Data-record: contains 80-character-information. No serial number is given.

Thus a 'computer-program' will have 'program-records' (a set of instructions) and 'data-records'.

4.2 EDITING

Editing of a file may involve the following main functions:

1. ADD a number of records after a specified record-number in a file.

2. MODIFY a record of specified record-number, or replace the record of specified record number by the given record.

3. DELETE a number of records of specified record numbers.

4. COPY a file.

All the reords are written on the take-up-reel after blanking the last four columns.

EDIT program can perform the above functions according to the edit-information supplied by the user.

4.3 ASSUMPTIONS

Programs have been developed assuming certain common things so as to make the programs compact and fast-run.

We assume that the user will read his/her 'program' starting from the first instruction. Hence edit-information supplied by the user will be in ascending order. For instance:

```
File-identification number
ADD 2 records after n1
...      ...      ...
...      ...      ...
DELETE 3 records n4 n3 n2
MODIFY a record        n5
...      ...      ...
:
End of edit
```

Here $n_1 < n_2 < n_3 < n_4 < n_5$.

File reel is mounted on tape - 0, and take-up reel on tape - 2. Content of the file-reel is in the following form:

$$:TM:P_{fi}:TM:E_{fj}:TM:TM:$$

where

TM = Tape-mark

P_{fi} = i^{th} program-file

E_{fj} = Edit-information for j^{th} program-file

$i = 1, 2, 3, \ldots$

$j \leq i$

First record is a tape-mark followed by a set of records of a 'program' file or 'Edit-file'. Two files are separated from each other by a tape-mark. Edit-file can be written anywhere after the corresponding program-file. End of the files is indicated by two consecutive tape-marks. There need not be any edit information in case editing is not required.

4.3.1 Sense switches are used for fast processing and keeping some options to the operator.

Sense-Switch 1 (SS1): 'ON' implies straight-copy assuming no edit-information.

'OFF' implies that edit-information has been furnished.

Sense-Switch 2 (SS2): 'ON' implies that editing of a specified file is required.

'OFF' implies that no file-number is specified.

In case of SS2 'ON', operator is required to write the desired file-number on the console typewriter.

4.4 EDIT-INFORMATION

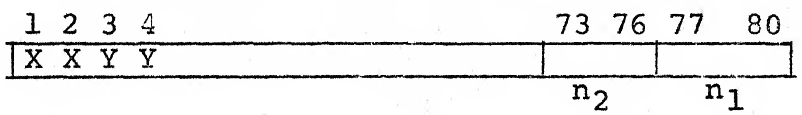


Figure 4.1: Format of a command-record in an edit-file

XX is a numeric code for edit-operation. List of such codes is given below:

Code	Edit-operation
00	Copy the file (a redundant provision)
05	ADD 'YY' records after n_1
10	DELETE 'YY' records specified as $n_1, n_2, \ldots$
15	MODIFY a record n_1
99	End of edit file.

YY denotes the number of records

n_i is a four-digit serial number

First record of an edit file is same as that of the corresponding 'program' file except in last five positions. Last five places are reserved for EDIT0 to EDIT1.

EDIT0 implies that it is the first record of an edit-file, but no further edit information is furnished and the straight copy of the file is desired.

EDIT1 implies that it is the first record of an edit-file and edit-information is given.

4.4.1 EXECUTION

Whenever the first record containing the file identification number of a program file is read, it's stored in the memory and the search for the corresponding edit file is made. In case it's found with same file identification number and EDIT written in 76-79 positions, the whole edit file is

dumped into the memory and the tape is brought back to the previous 'program'-file. Editing takes place and each record undergoes the operation of blanking the last four positions which were used for serial-number. This blanking-operation is necessary to make the records computer processable.

EDIT program can point out the following unusual conditions during the execution:

(a) Excess records after the command-record.

For instance:

```
  ADD 2 records after n1
  THIS RECORD IS ADDED
  THIS RECORD IS ALSO ADDED
→ LOOK, HERE IS AN EXTRA RECORD
  MODIFY a record n2
  MODIFIED record
  .
  .
  .
```

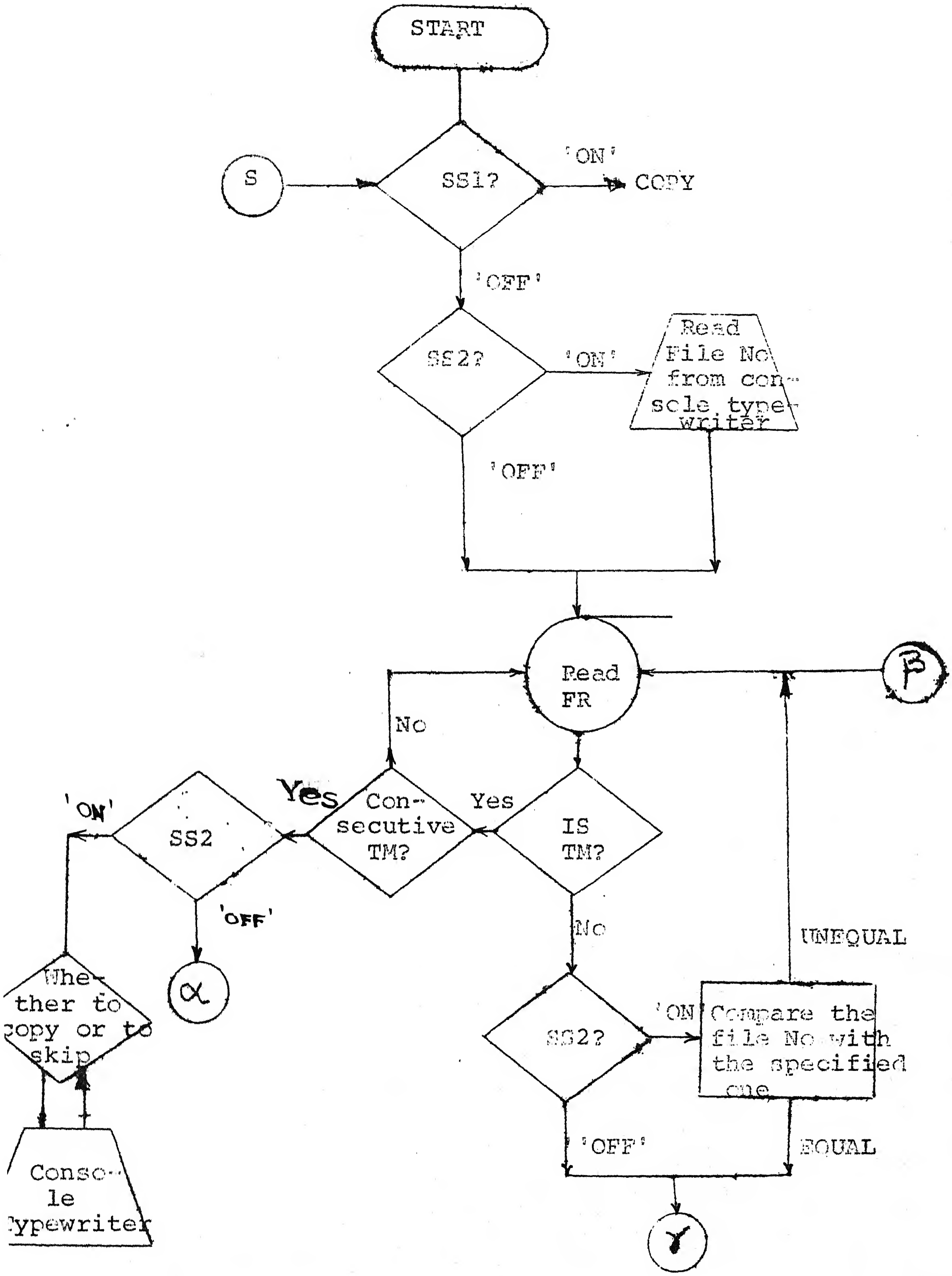
First command-record is required to be followed by only two records. Third record is in excess.

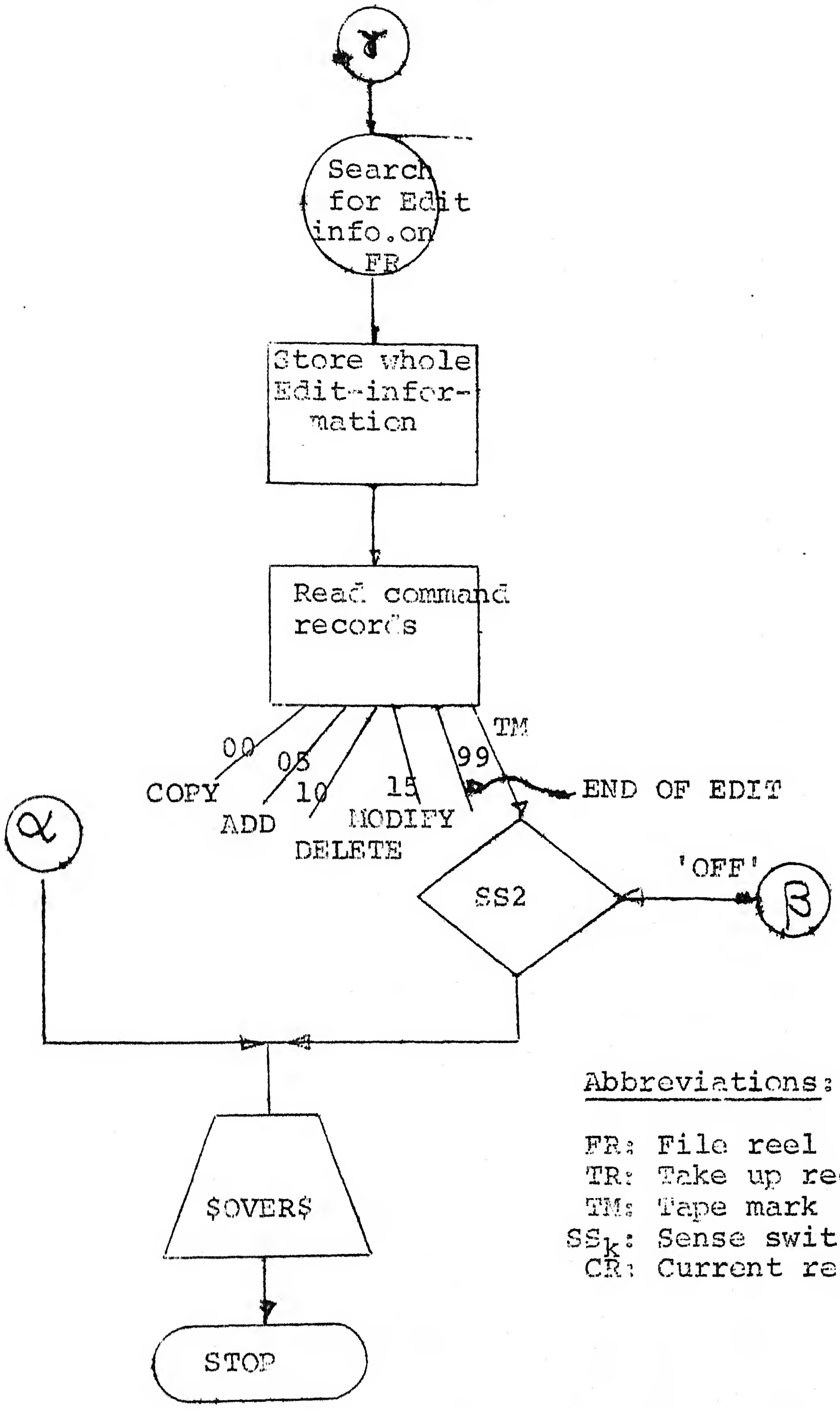
(b) Inadequate-information -

For instance:

```
ADD 3 records after n1
ADDITION OF ONE RECORD ONLY
DELETE 3 records n2 n1
```

After ADD-instruction, only one record is given instead of 3 records. DELETE - instruction has only n_1 and n_2 record-numbers. Third record-number is missing.


START
S
SS1?
'ON'
COPY
'OFF'
SS2?
'ON'
Read File No from console typewriter
'OFF'
Read FR
β
No
Yes
Consecutive TM?
Yes
IS TM?
'ON'
SS2
'OFF'
α
Whether to copy or to skip
Console Typewriter
No
UNEQUAL
SS2?
'ON'
Compare the file No with the specified one
'OFF'
EQUAL
γ



<u>Abbreviations:</u>

FR: File reel
TR: Take up reel
TM: Tape mark
SS_k: Sense switch k
CR: Current record

Figure 4.1(a): Flowchart of EDIT-program

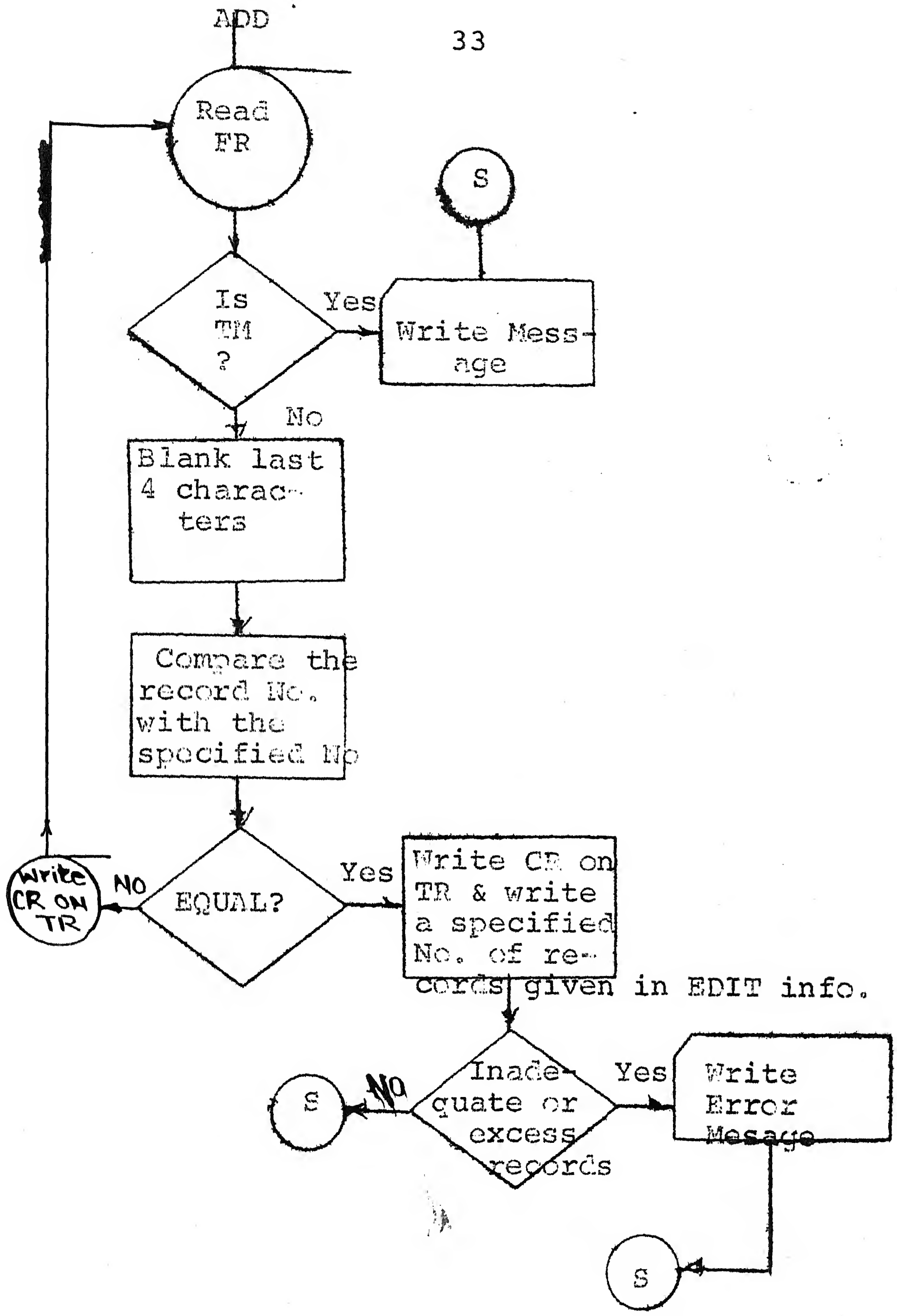
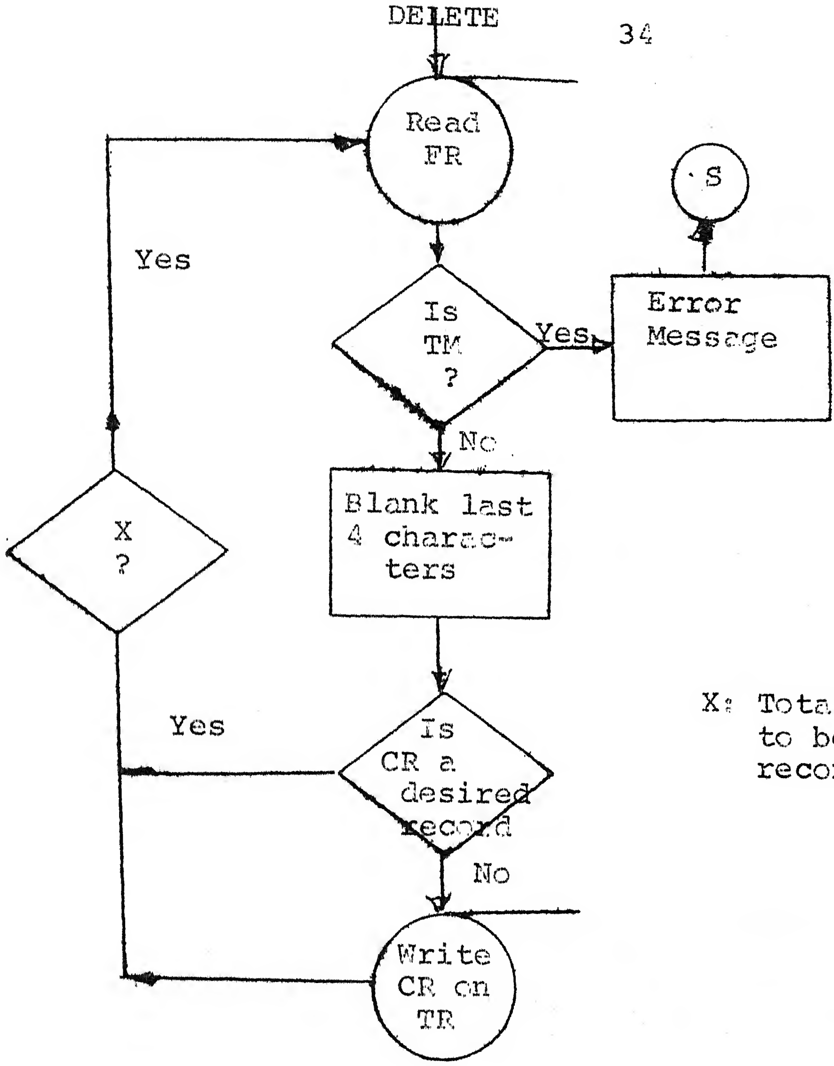
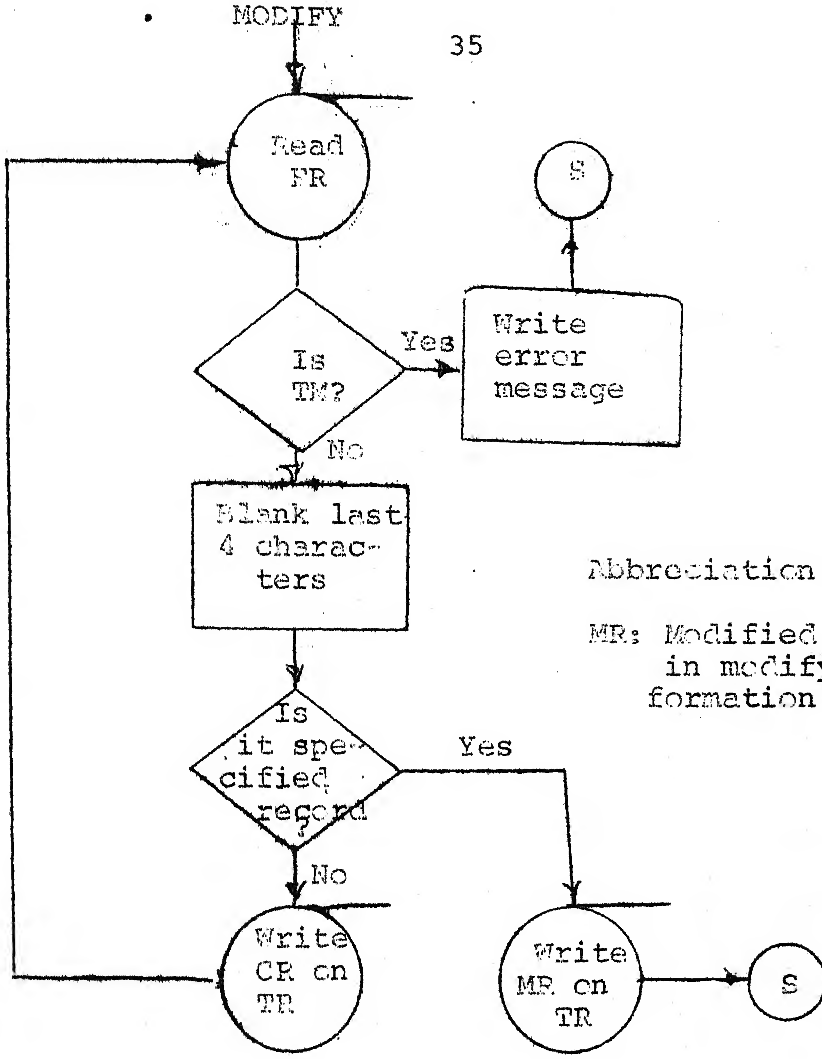


Figure 4.1(c): ADD-operation



X: Total number of records to be deleted > number of records deleted so far.

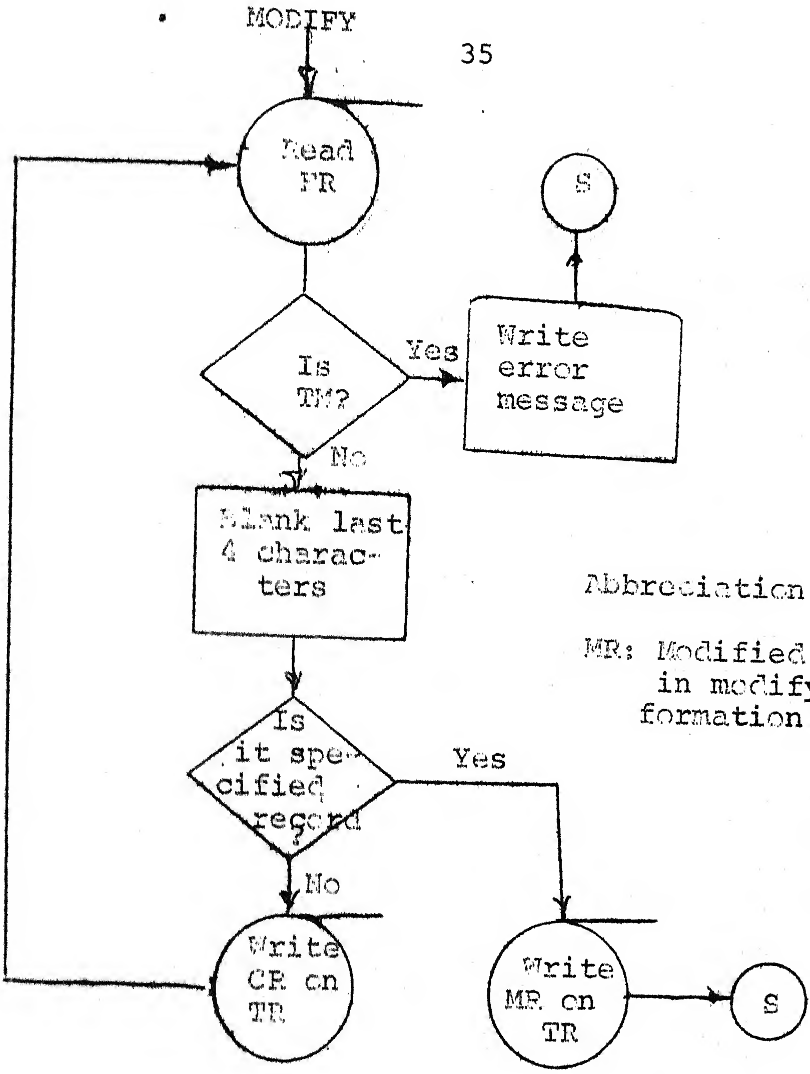
Figure 4.1(d) DELETE operation



Abbreciation :

MR: Modified record in modifying in-formation.

Figure 4.1(e): MODIFY-operation



Abbreviation :

MR: Modified record in modifying information.

Figure 4.1(e): MODIFY-operation

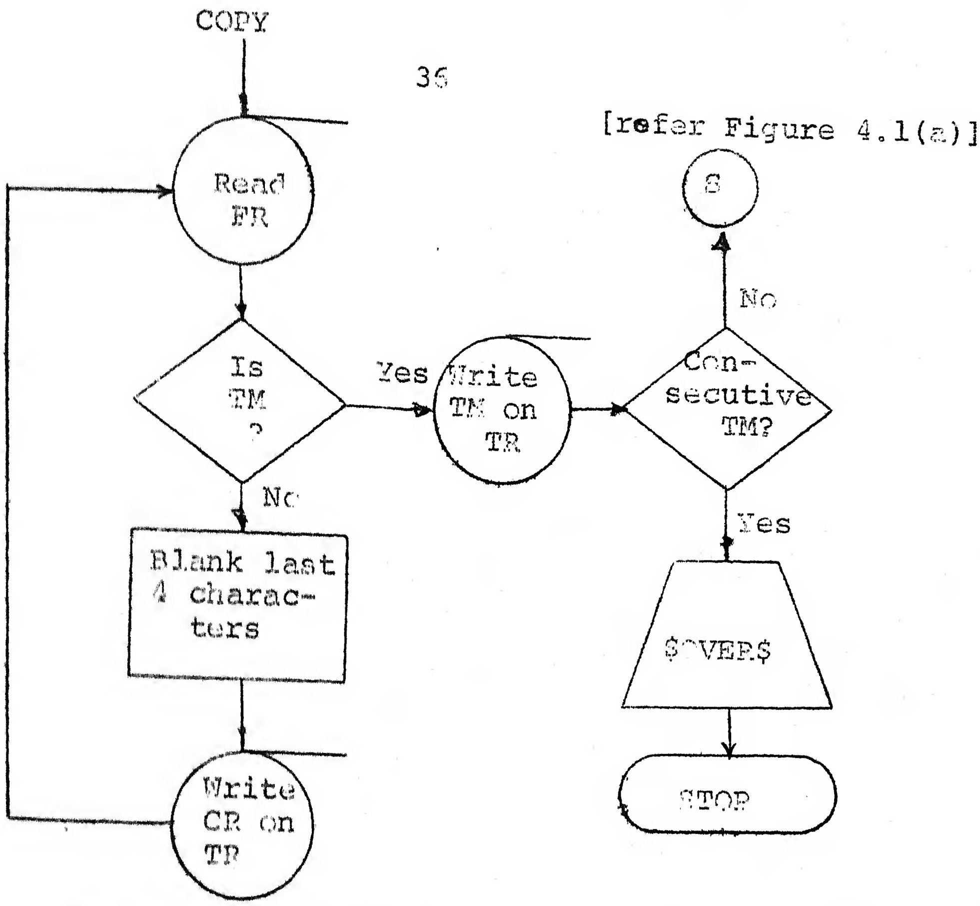


Figure 4.1(b): COPY-operation

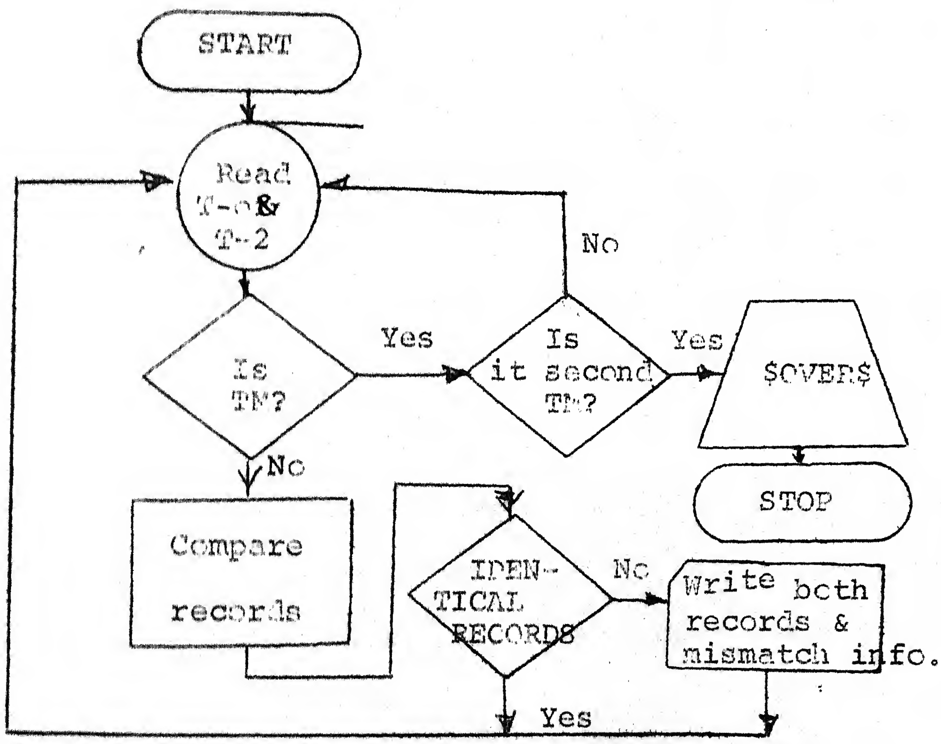


Figure 4.2: FILE-verification

(c) 'TAPE IS BAD' is typed out in case it is found so after a fixed number (10) of trials.

(d) If the specified file-identification number is not found on the file-reel, it is pointed out with the following message:

'XXXXXX/YY is NOT ON TO'.

End of edit is indicated by $OVER$ being typed out on the console typewriter.

4.5 FILE VERIFICATION

Punched cards are verified on a Verifier machine which is similar to the card punch except that it is equipped with a sensing device to only read holes. Punching does not take place during verification.

In case of tape recording, data of a source document is recorded by two operators independently. These two data files are mounted on tape-0 and tape-2.

Records from each tape are read and compared. If there is any mismatch in particular position, it is pointed out through punch-output or through print-output. A $-sign is written just above the character found in error (unequal). Record position after the file identification number and the location numbers where the unequal characters are found. are also mentioned.

File-verification can point out the following conditions:

(a) Records mismatched

Both the records are written out with a \$-sign above every location of mismatching. Record-positions and locations in error are also pointed out.

For instance

```
                    0007 COL.- 7 10

                          $  $
                    143.726Ø83.2
                    143.727Ø88.2
```

This points out that there are mismatches in columns or positions 7^{th} and 10^{th} in a record which is at the 7^{th} place after the file-identification number.

(b) **Records** in excess on a tape are written out with a ≠ (record mark) written corresponding to the other tape.

e.g.

```
      43.56        3.82        7.845
      ≠
```

This points out that there is an extra record on tape-0.

(c) Utmost 4 mismatches are allowed. If there are more than 4 mismatches in two consecutive records, current file is skipped and next file (if any) is to be verified. The message written out is 'HEAVY MISMATCH ONWARDS'.

(d) End of file-verification is indicated by \$OVER\$ being written on the console-typewriter.

Mode of output: Output can be on punched cards or on console typewriter.

Sense-switch 4 (SS4): 'ON' implies the output on punched cards.

'OFF' implies the cutput on the console typewriter

4.6 DATA CORRECTION

After file verification, the mismatch information is received by the user. It is user to verify the records and to furnish the information for data correction on any one of these tape reels. Preferably tape with minimum number of wrong records is selected.

Program for data correction is included in the EDIT-program. Data correction program in the EDIT is executable when SS3 is 'ON'. It is similiar to the MODIFY-subprogram except that records are to be counted as no serial number is given.

When record is read from data reel, record-counter is incremented and compared with the specified number. Tape is backspaced if both the numbers are found equal and the data record given in the data correction (Modifying) information, is written over.

4.6.1 Data reel is mounted on tape-2 and the modifying informations on tape-0.

Format of the modifying information

TM : MI : TM
or
MI : TM : TM

where TM = Tape mark

MI = Modifying information.

Modifying information may be for several files. It is in the sequence of the recorded files. A file corresponding to which no modifying information is given is skipped.

Format of the instruction record is as below:

```
1           12         7376 77 80
$UUUUUU/XXYY    ...      n2    n1
```

$ indicates the start of a new file of given file number in the next 9 places.

UUUUUU = 6-character user number

XX = 2-digit file identification number

YY = Number of records to be modified

$(YY)_{max} = 17$

For continued modification in a file, a new instruction is added whose format is as below

```
1 2 3        73  76  77   80
= Y Y        n2       n1
```

= sign denotes the continuation of the modifying information.

YY = number of records to be modified

$(YY)_{max} = 19$

n_1, n_2 ... are the record positions after the file identification recrd. These numbers are in ascending order.

i.e. $n_1 < n_2 < n_3$ ...

Each instruction record is followed by the specified number of data records which are required to replace the records at the specified positions.

CHAPTER 5

POWER SUPPLIES

UNIT-1 and UNIT-2 required four stablised power supplies of the voltages -27 volt, -13 volt, +13 volt and +3.6 volt. Power supplies of satisfactory regulation upto 1.5 amp have been designed and fabricated. A current limiter has been used to limit the current to 1.5 amp. A flip flop is used to bring the series power transistor and the associated driver transistors in the cut off in case of overload.

5.1 PRINCIPLES OF OPERATIONS

Circuit diagram is illustrated in Appendix 6. Basically a series voltage regulator circuit has been used. Comparision element of the circuit is a difference amplifier which compares the voltage of the reference-zener with a voltage proportional to the output voltage. The change in the output voltage is reflected as the change in the base current which in turn changes the emitter-current. Increase in the output voltage corresponds to the decrease in the base current of the driver transistors and also to the decrease in the emitter current of the series power transistor. This will lower the output voltage to the normal value. Thus the output voltage is regulated.

5.2 OVERLOAD PROTECTION

Current limiter limits the current through the series power transistor so as to protect from the overload and short circuit. Considering the change in V_{BE} of the power transistor with the increase in the collector current (I_C), we suitably choose the series reistence (say about 0.2Ω) and the number of diodes connected between the output line and the base of the (lower) driver-transistor.

As current increases, voltage-drop across the series resistence also increases and at the limiting current value, diodes are forward biased. The current through the diodes is also limited because of the constant current source. As the V_{BE} of series transistor becomes constant due to forward biasing of the diodes, No further increase in current can take place hence load current becomes constant and power supply acts as a constant current source.

Power transistor is heated due to constant power dissipation and may be destroyed due to thermal-runaway, which may occur when the rate of increase of collector junction temperature exceeds the ability of the heat sink to remove the heat.

In order to reduce the wastage of power and protect the power transistor from thermal-runaway, an assymmetric flip flop has been used to bring the series transistors in

'cut-off'.

Let

V = output voltage

K = sample ratio

V_T = threshold voltage

In case of overload or short circuit, current limiter limits the load current and hence output voltage goes down. When $KV \leq V_T$, T_r goes in saturation and D_4 becomes forward biased to bring series transistors in 'cut-off'.

In normal condition T_{r6} is 'ON' and T_{r7} is 'OFF' while in short circuit condition T_{r6} is 'OFF' and T_{r7} is 'ON'.

To regain the normalcy after removing the short circuit or overload, a push button is pressed to give a positive pulse in case of pnp transistor or a negative pulse in case of npn transistors of the flip flops to the collector of the 'OFF'-transistor. This changes the state of the flip flop and D_4 will be reverse biased. Then voltage-regulator starts refunctioning.

Capacitor C_2 helps short duration pulses die-out so that unwanted transition does not take place.

Figure 5.1 shows the output V-I characteristic of the power supply. With change in load current there is very small change in the output voltage in the normal working region.

When load current exceeds the limiting current value, the power supply acts as a constant current source upto a certain voltage threshold, where flip flop operates and load current falls to I_{min} which is of the order of 30 to 40 ma.

5.3 DOUBLER

Doubler is used to get higher constant voltage to bias the constant current source. This arrangement reduces the output resistance and hence improves the voltage regulation for all load currents.

5.4 Heat sinks have been made of aluminium and black anodized to lower its thermal resistance. Heat-sinks are vertically fixed in the container which reduces the thermal resistance by an order of 10% because of increased convection. Heat-sinks of two different designs have been fabricated. Transformer required for these power supplies, has also been designed and fabricated.

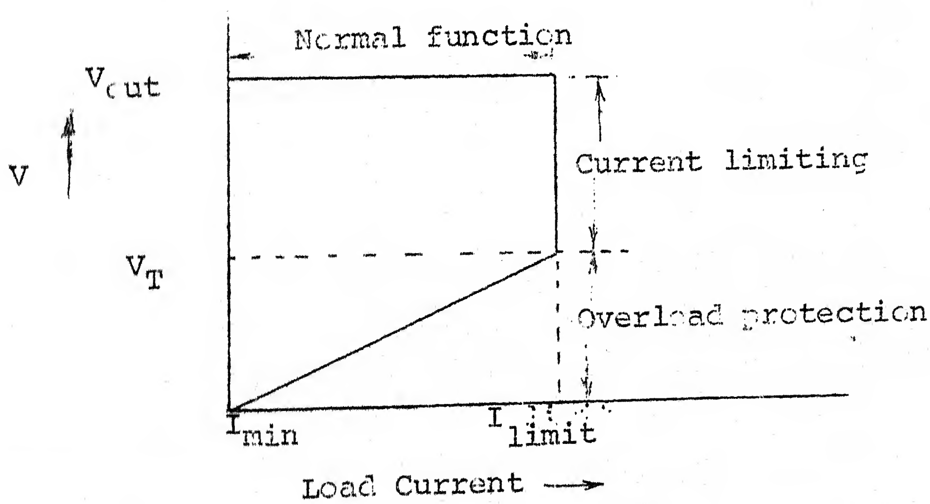


Figure 5.1: Fold-back characteristics of power supply.

5.5 MODIFICATION SUGGESTED

It is felt that the use of a flip flop for overload protection requires manual resetting after removing the overload or short circuit. Use of a monostable instead of a flip flop will automatically reset the power supply after removing the overload or short circuit.

CHAPTER 6

CONCLUSION

The interface unit designed as part of this thesis functions satisfactorily. It is felt that it is difficult to read-back the signal from the audio tape accurately by applying the NRZ (non-return-to-zero) recording technique wherein loss of one positive pulse might result in the loss of many bits. Frequency modulation technique for recording on audio-tape would increase the reliability of the recorded information.

Check-bit should be added to the 6-bit code. Thus a character comprising 7-bits should be recorded on the audio-tape.

In the present interface unit, if a write check occurs while writing on digital tape there will be a problem as we want to run the audio tape continuously. The problem may be solved by adding another buffer in the interface unit. Considering 200 bpi, it takes 16.2 ms to write a 80-character record on digital magnetic tape. Whenever write-check occurs tape is to be backspaced and the same information is rewritten. This takes 70+16.2 = 86.2 ms. We can try 3 times to write the information. In case of a 3rd write check, it would be required to erase forward which takes about 115 ms and same

information is rewritten. At this point, 3*86.2+115+16.2 ≈ 390mse would have elapsed while available time is about 402 ms. If a write check occurs while writing after erase forward, tape is assumed to be bad and further processing is stopped. If no write check is encountered, the job is complete.

The proposed system is particularly suited for data recording. The verification and edit programs give the system more flexibility compared to the punched card system for data.

REFERENCES

1. Satish Chandra, "An Audio Tape Storage for Digitally Coded Alphanumeric Data - A Feasibility Study, Part I"

2. Krishna Kumar, A.V., "An Audio Tape Storage for Digitally Coded Alphanumeric Data - A Feasibility Study, Part II". Master's Thesis, EE-70/217 MT, IIT Kanpur.

3. Millman J. and Taub H., "Pulse, Digital and Switching Waveforms", McGraw-Hill Book Company, N.Y., 1965.

4. Pear Jr., C.B., Editor, "Magnetic Recording in Science and Industry", Reinhold Publishing Co., 1967.

5. Middlebrook, R.D., "Design of Transistor Regulated Power Supplies", Proc. of IRE, November, 1957, Vol. 45-3, pp 1502.

6. Texas Instruments, "Transistor Circuit Design", McGraw-Hill Book Company, Inc.

APPENDIX 1

IBM TAPE CODE

Character	C	B	A	8	4	2	1	Character	C	B	A	8	4	2	1
0	0	0	0	1	0	1	0	G	1	1	1	0	1	1	1
1	1	0	0	0	0	0	1	H	0	1	1	1	0	0	1
2	1	0	0	0	0	1	0	I	0	1	1	1	0	0	1
3	0	0	0	0	0	1	1	.	1	1	1	1	0	1	1
4	1	0	0	0	1	0	0	)	0	1	1	1	1	0	0
5	0	0	0	0	1	0	1	-	1	1	0	0	0	0	0
6	0	0	0	0	1	1	0	J	0	1	0	0	0	0	1
7	1	0	0	0	1	1	1	K	0	1	0	0	0	1	0
8	1	0	0	1	0	0	0	L	1	1	0	0	0	1	1
9	0	0	0	1	0	0	1	M	0	1	0	0	1	0	0
=	1	0	0	1	0	1	1	N	1	1	0	0	1	0	1
'	0	0	0	1	1	0	0	O	1	1	0	0	1	1	0
+	0	1	1	0	0	0	0	P	0	1	0	0	1	1	1
A	1	1	1	0	0	0	1	Q	0	1	0	1	0	0	0
B	1	1	1	0	0	1	0	R	1	1	0	1	0	0	1
C	0	1	1	0	0	1	1	$	0	1	0	1	0	1	1
D	1	1	1	0	1	0	0	*	1	1	0	1	1	0	0
E	0	1	1	0	1	0	1	blank	1	0	1	0	0	0	0
F	0	1	1	0	1	1	0	/	0	0	1	0	0	0	1

Character	C	B	A	8	4	2	1
S	0	0	1	0	0	1	0
T	1	0	1	0	0	1	1
U	0	0	1	0	1	0	0
V	1	0	1	0	1	0	1
W	1	0	1	0	1	1	0

Character	C	B	A	8	4	2	1
X	0	0	1	0	1	1	1
Y	0	0	1	1	0	0	0
Z	1	0	1	1	0	0	1
,	0	0	1	1	0	1	1
(	1	0	1	1	1	0	0

Figure A.1: 7 Bit codes for the 48 characters as they should appear on the digital tape.

APPENDIX 2

FREQUENCY MODULATION

In frequency modulation, the writing currents and hence the recorded flux changes direction in the middle of each '1' bit being stored and does not change the direction in the middle of each bit period if '0' is being recorded. Flux always changes direction between each bit period. Thus the recorded pattern is frequency modulated between f for a train of 0's and 2f for a train of 1's. Value of the output digits is determined by ANDing the read voltage with the clock. Concidence with zero output voltage indicates '0' bit and concidence with either positive or negative pulse represents a '1'.

Advantages:

1. FM provides more redundancy than NRZ method.

2. bpi $\leq$ ppi $\leq$ 2bpi

   bpi = bit per inch, ppi = pulse per inch

This pulse denisity pass band minimizes low frequency base-line distortions. Definition of signal peaks is improved.

Above reasons insure the RELIABILITY of frequency modulation recording.

3. Balanced recording current allows us to drive the write-head with a transformer without the need for d-c restoration.

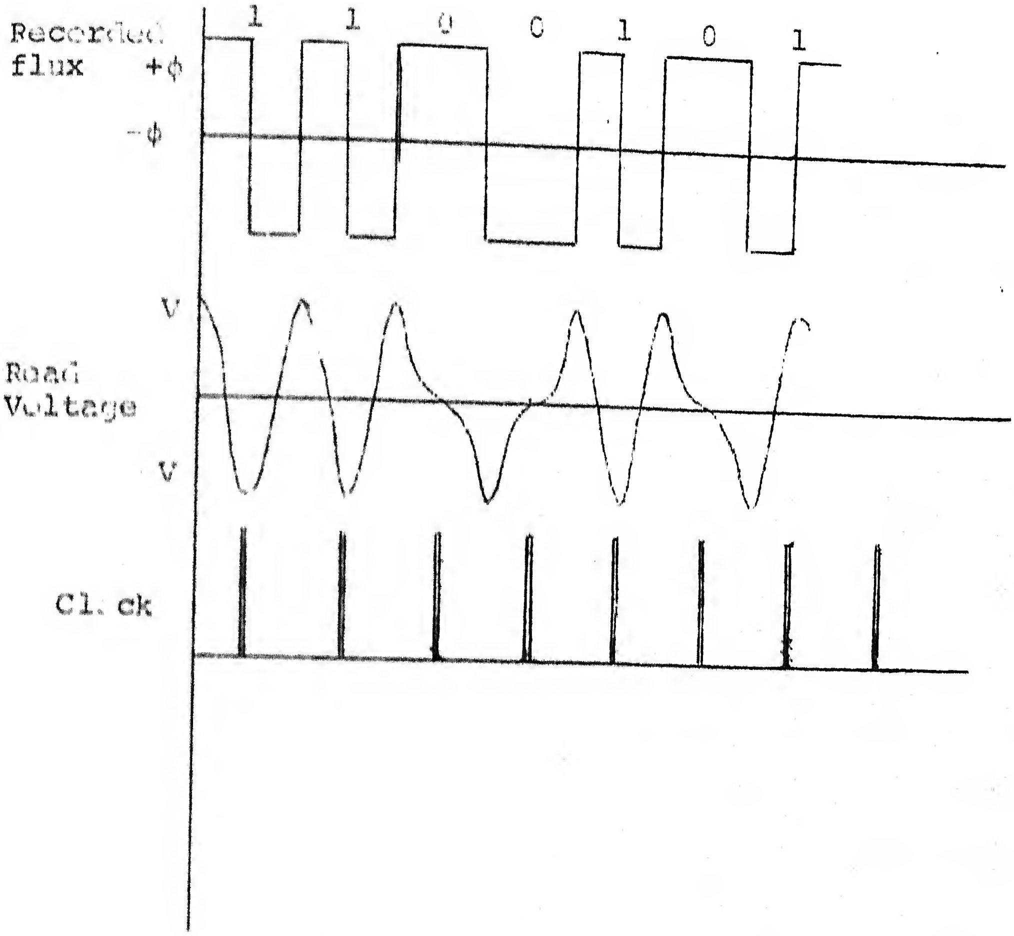


Figure A.2(1): Recording by frequency modulation technique and the read voltage wave form.

APPENDIX 3

CHARACTERISTICS OF TAPE UNIT 7330 USED WITH IBM 1620

Tape speed = 36 inches/sec

Select Density

Low: 200 bpi

High: 556 bpi

@ 200 bpi period of the clock = 138.89μsec.

Buffer - transfer time = 81 * 138.89

(80 chracters plus horizontal parity) = 11.25 m sec

@ 556 bpi period of the clock = 49.959 μsec

≃ 50 μsec

Buffer - transfer time = 4.0456 msec

Record to be written	Write Delay 5 msec	Forward Stop 4 msec	Forward Stop Delay 6.6 ms	Last card written & checked 8.3 ms	Record written

↑

Total time required for start and stop of the tape = 23.9 msec.

APPENDIX 4

INTEGRATED CIRCUIT SHIFT REGISTER SPECIFICATIONS

MOS integrated circuit Dual 16 Bit Static Shift Register.

Type TMS 1B 3016 LA

Description

The TMS 1B 3016 LA consists of two separate 16 bit static shift registers with independent input and output terminals, and common clocks, power and ground. Two power supplies and two external clocks are required for operation with a third clock generated internally.

Transferring data into the register is accomplished when the $\emptyset_1$ clock is at a logical 1. Shifting the data occurs when the $\emptyset_1$ clock is momentarily pulsed to logical 1 and the $\emptyset_2$ clock to logical 0. For long term data storage, the $\emptyset_1$ clock must be held at logical 'O' and $\emptyset_2$ clock must be held at logical 1. Output data appears on the negative going edge of the $\emptyset_2$ clock pulse.

Recommended operating conditions:

	MIN	NOM	MAX	UNIT
Supply voltage V_{DD}	-12	-13	-14	V
Supply voltage V_{GG}	-26	-27	-28	V
Width of data pulse t_p(data)	0.4			us
Width of clock pulses t_p(clock $\emptyset_1$)	0.4		10	us
t_p(clock $\emptyset_2$)	0.4			us

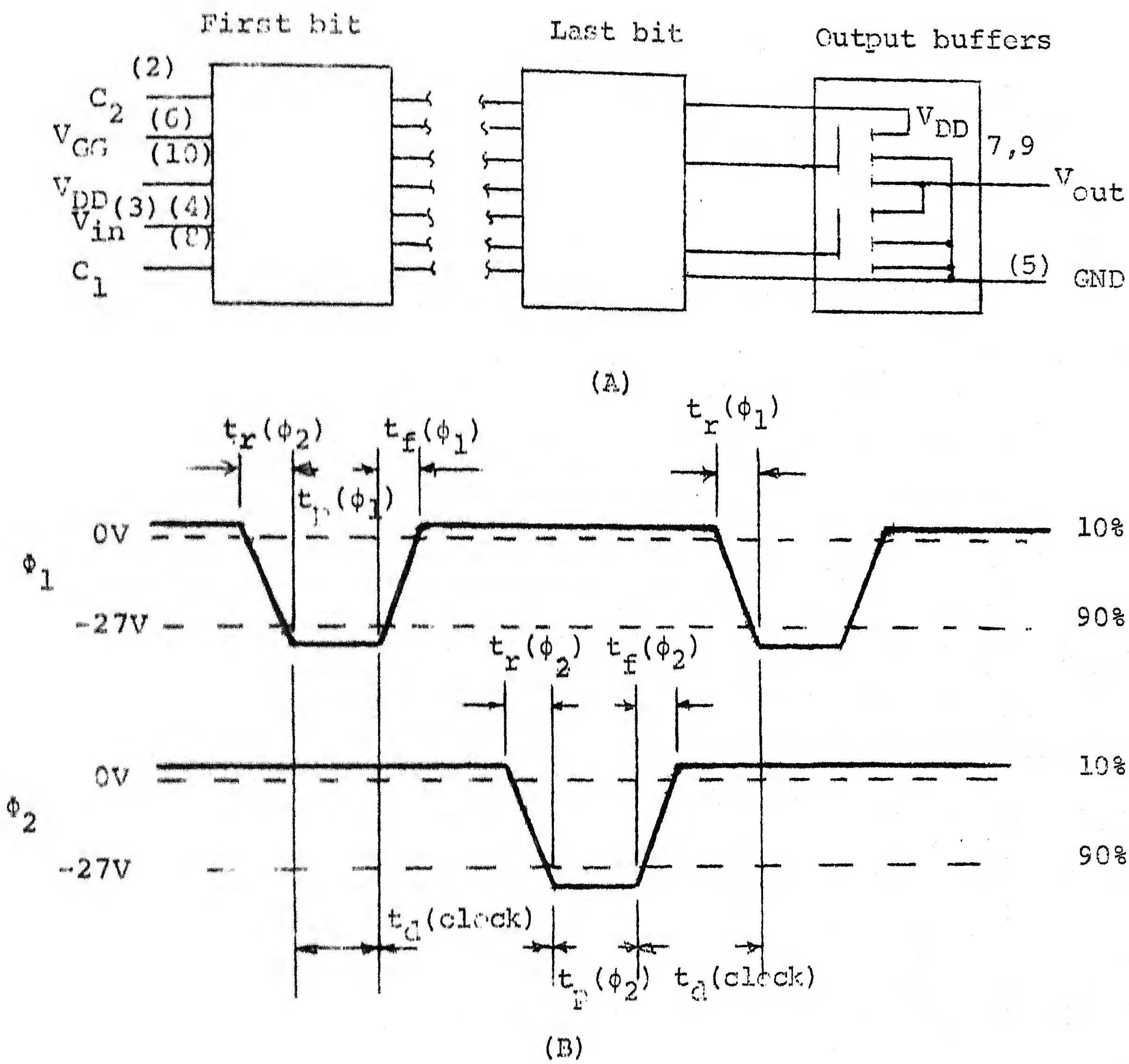
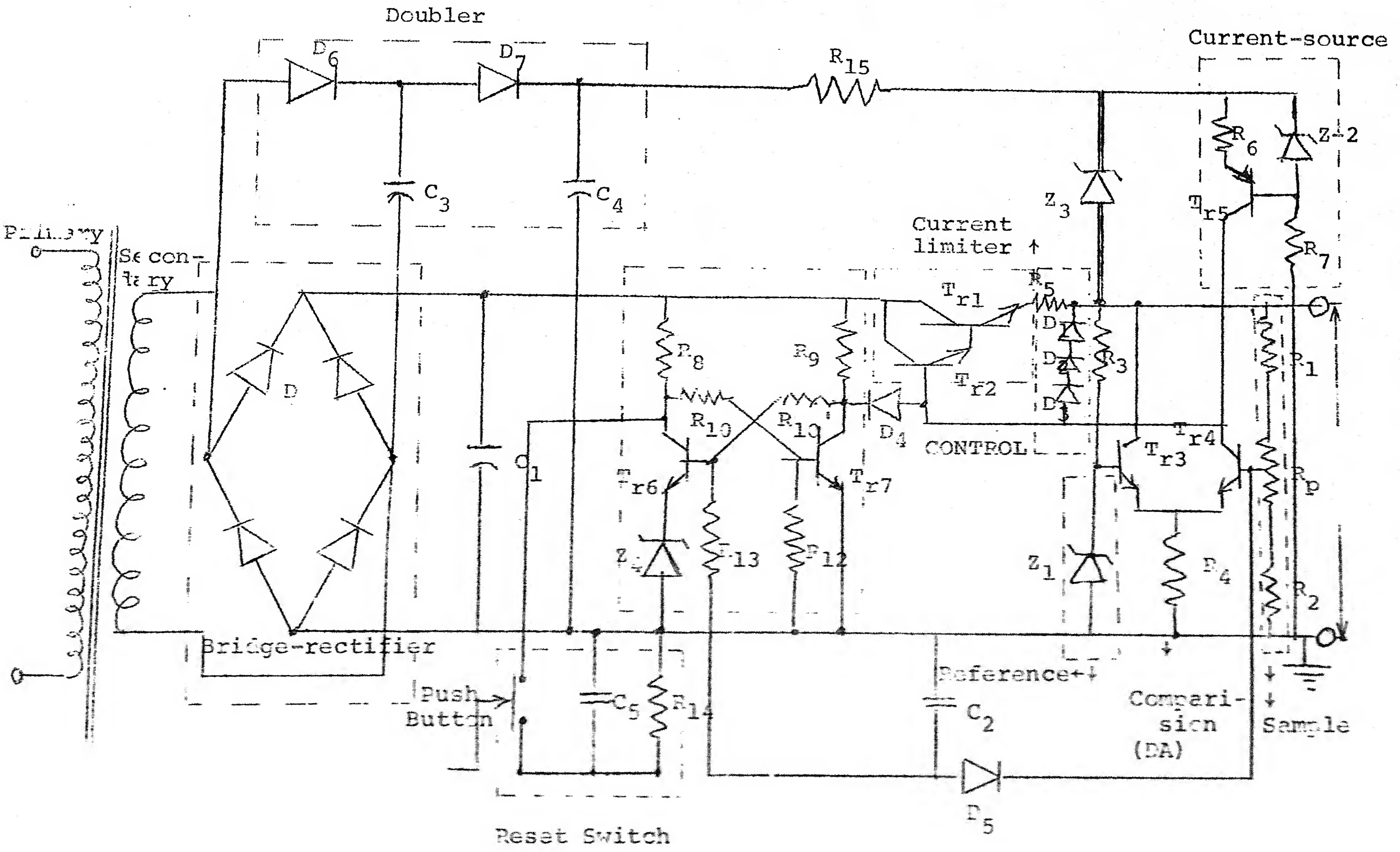


Figure A.4.1: (A) Functional Block diagram
(B) Timing diagram of ϕ_1 and ϕ_2



R_{13} determines V_T
R_5 determines R_{limit}

Table: Values of Components Used in Power Supply

Components	-27V	-13V	+13V	+3.6V
R_1	510Ω	--	510Ω	--
R_2	510Ω	--	680Ω	--
R_p (variable resistance)	500Ω	2KΩ	500Ω	580Ω
R_3	600Ω	240Ω	150Ω	100Ω
R_4	750Ω	560 Ω	680Ω	240Ω
R_5	0.18Ω	0.18Ω	0.18Ω	0.18Ω
R_6	510Ω	510Ω	510Ω	510Ω
R_7	2500Ω	700Ω	600Ω	75Ω
R_8	7.5K	2.2K	1.8K	750Ω
R_9	5.1K	4.3K	5.1K	3.9K
R_{10}	56K	27K	22K	2K
$R_{10'}$	100K	39K	27K	10K
R_{12}	3.9K	2K	1.5K	27Ω
R_{13}	3K	12K	10K	240Ω
R_{14}	68K	68K	68K	68K
R_{15}	1500K	--	400Ω	--
D's	1N1581	1N1581	1N1581	1N1581
D_6, D_7	EC051	--	EC051	EC051
D_5	CD31	--	CD31	--
C_3, C_4	1000μf	--	1000pf	--

Components	-27V	-13V	+13V	+3.6V
C_2	330pf	330pf	330pf	-
C_1	20000µf	-	4500µf	-
Z_1	1Z6.8V	1Z6.8V	1Z7.5	1Z3.3
Z_2	1Z3.6V	1Z3.6V	1Z3.6V	1Z3.6V
Z_3	SZ131	-	SZ131	-
Z_4	1Z6.2V	1Z6.2V	1Z6.8V	1Z3.3V
T_{r1}	2N1905	2N1905	2N5037	2N5037
T_{r2}	SK100	SK100	CIL452	CIL452
T_{r3}, T_{r4}	2N3250	2N995	CIL452	CIL473
T_{r5}	2N363	2N363	2N3638	2N995
T_{r6}, T_{r7}	2N3250	2N3638	CIL511	CIL453

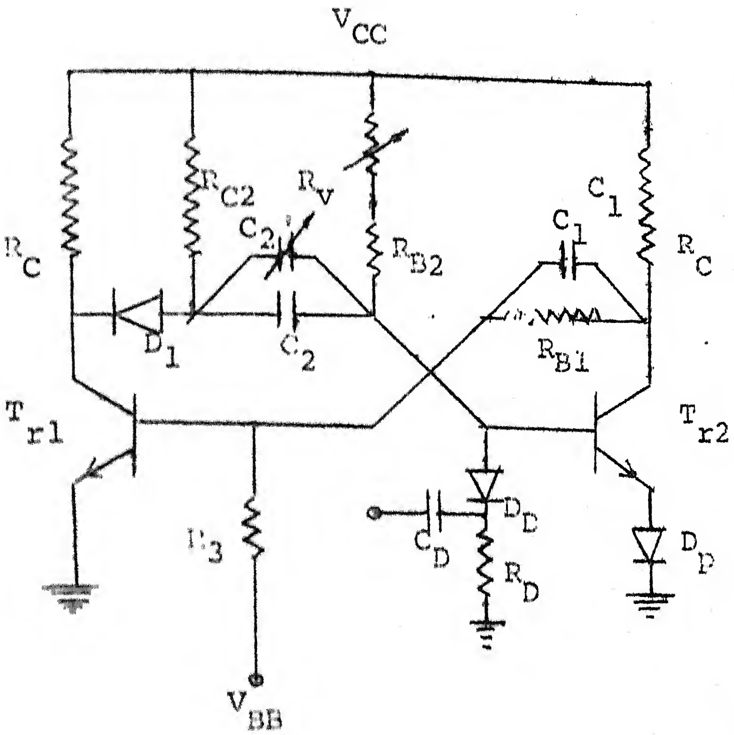


Figure A.6(1): Circuit of the monostable

MS	1	2	3	4	5
V_{CC}	+3.6V	-13V	-27V	-27V	+3.6V
V_{BB}	-13V	+13V	+13V	+13V	-13V
T	.15ms	5μs	5μs	15μs	5ms
T_{r1}, T_{r2}	CIL732	2N995	2N3250	2N2250	CIL732
D_D, D_P	1N270	1N270	1N270	1N270	1N270
R_{B1}	15K	62K	100K	100K	10K
R_{B2}	15K	56K	150K	150K	8.2K
R_V	5.1K	-	-	-	3.3K
R_3	680K	390K	680K	680K	470K
R_{C2}	820oh	5.1K	10K	10K	-
R_D	100K	100K	100K	100K	270K
C_1	39pf	7.5pf	22pf	7.5pf	10pf
C_2	.01μf	22pf	39pf	120pf	1μf
C_2'	-	7-70pf	7-70pf	7-70pf	-
C_D	22pf	56pf	39pf	39pf	390pf

Table A.6(1) Component values of Monostables

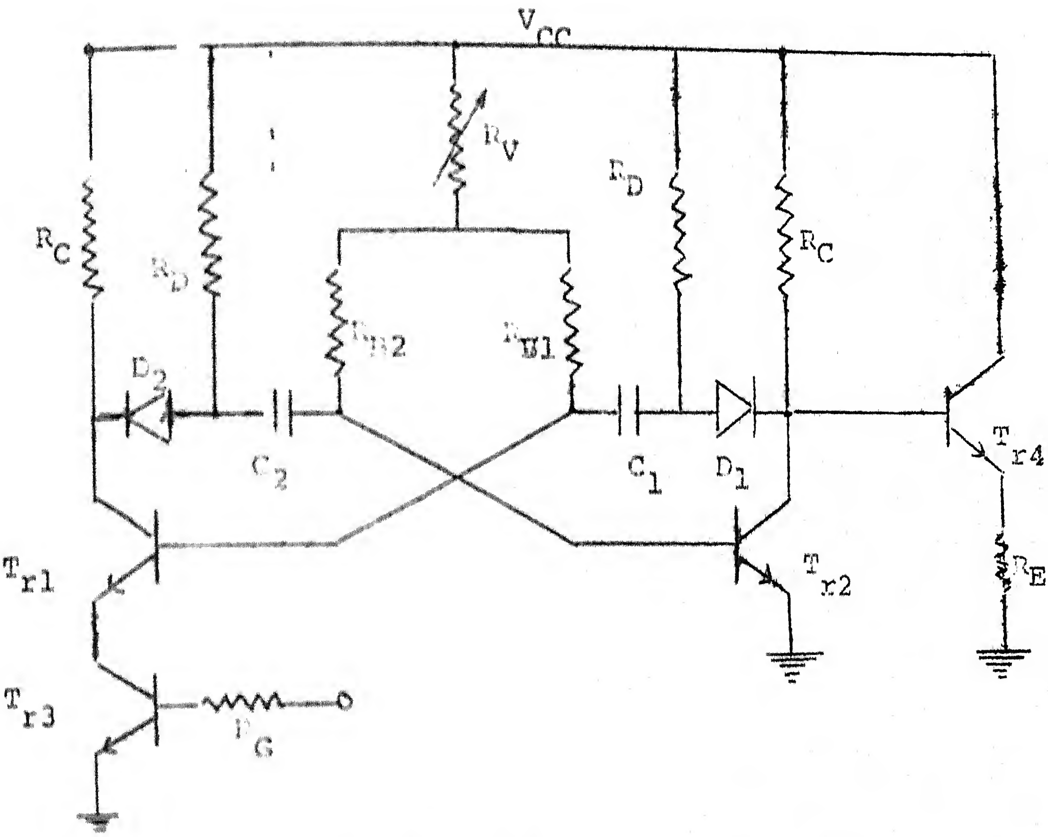


Figure A.6(2): Circuit of the gated Astable.

GA	1	2	3
V_{CC}	+3.6V	+3.6V	+3.6V
T	0.5ms	50μs	140μs
T_{r1}, T_{r2}, T_{r3}	CIL732	CLL732	CIL732
D_1, D_2	1N270	1N270	1N270
R_C	680ohm	750ohm	750ohm
R_{C2}	1.5K	2K	3K
R_D	10K	8.2K	12K
R_V	3.3K	3.3K	3.3K
R_G	3.9K	3.9K	3.9K
R_E	1.2K	1.2K	1.2K
C_1	68000pf	4700pf	6800pf
C_2	10,000pf	6800pf	6800pf

Table A.6(2): Component values of gated astables

APPENDIX 7

IC's USED IN THE PROJECT

The IC's used in this project belong to the MRTL family of resistor-transistor logic. The 'Function and Characteristics' and the 'Maximum Ratings' for the IC's used are given in Table 1 and 2 respectively. The logic diagrams are shown in Figure A-I.1 to A-I.5.

Table 1: Functions and characteristics

$V_{CC} = +3.6V \pm 10\%$. $T_A = 25°C$.

Function	Number	FAN-OUT Each Output	Propagation Delay t_{pd} ns type	Total Power Dissipation mw type
Quad 2-Input NOR Gate	MC824P*	5	12	100/50[1]
Dual 4-I ut NOR Gate	MC825P	5	12	60/15[1]
Hex-Inverter	MC889P	5	12	130/15[1]
Dual J-K Flip Flop	MC890P	3	35	182/158[2]
Dual Buffer	MC899P	25	15	50/90[1]

*Suffix P denotes Plastic Package.

1. Inputs High/Inputs Low
2. Only Clock Inputs High/Inputs Low

Table.2 : MAXIMUM RATINGS(T_A= 25°C)

RATING	SYMBOL	VALUE	UNIT
Input Voltage	-	±4	Vdc
Power Supply Voltage(Pulsed≤1Sec)	-	+12	Vdc
Operating Temperature Range	T_A	0 to 75	°C
Storage Temperature Range	T_{stg}	-55 to +125	°C

NOTE : In all Logic Diagrams shown, numbers at ends of terminals represent pin numbers. Number in parenthesis indicates loading.

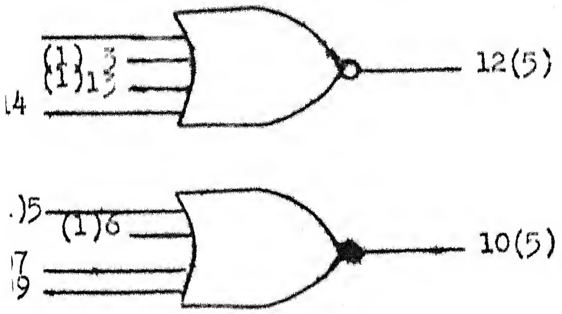


Figure A-I.1 :Logic Diagram of Dual 4-Input NOR Gate MC825P

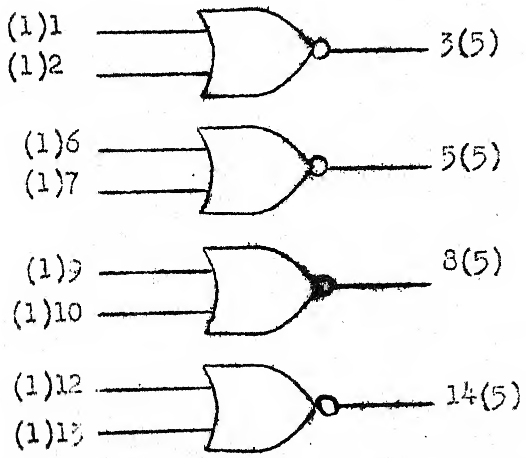


Figure A-I.2 :Logic Diagram of Quad 2-Input NOR Gate. MC824P

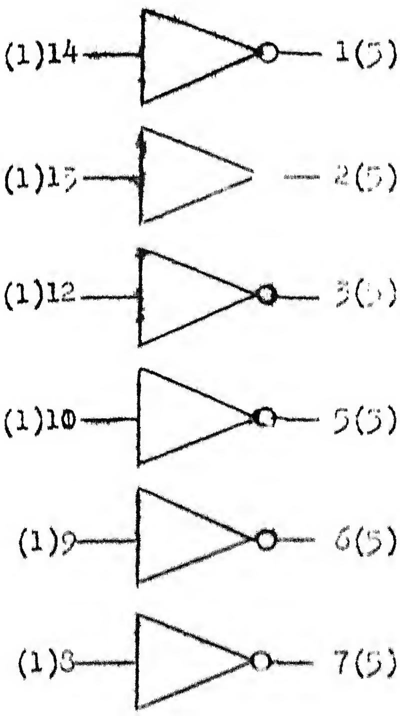


Figure A-I.3 :Logic Diagram of Hex Inverter.MC889P

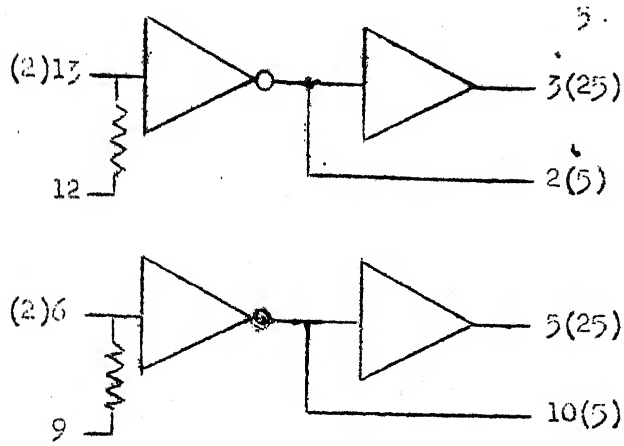


Figure A-I.4 :Logic Diagram of Dual Buffer.MC899P

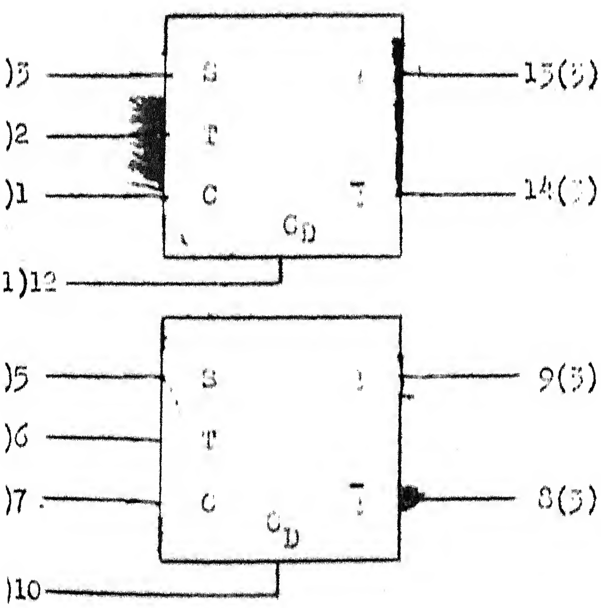


Figure A-I.5 :Logic Diagram of Dual J-K Flip-Flop. MC890P

CLOCKED INPUT OPERATION[1]

t_n[2]		t_{n+1}[2]	
S	C	Q	$\bar{Q}$
1	1	Q_n[3]	$\bar{Q}_n$
1	0	1	0
0	1	0	1
0	0	$\bar{Q}_n$	Q_n[3]

1. Direct Input(C_D) must be low.

2. The time period prior to the negative transition of the clock pulse is denoted t_n and the time period subsequent to this transition is denoted t_{n+1}

3. Q_n is the state of Q output in the time period t_n.

```
*
*                          E D I T
*
****************************************************************************
*05=ADD       10=DELETE       15=MODIFY         00=COPY       99=END OF EDIT
*123456789                     ................                         79 8
****************************************************************************
*00
*05XX                                                                      N
*10XX                                                       N3      N2     N
*15                                                                        N
*99
*EEG135/01                                                             EDIT
*EEG135/01                                                             EDIT1
* KEEP SWITCH-3 ON FOR STRAIGHT MODIFICATION OF THE DATA FILE
* MODIFYING INFORMATION IS AS BELOW -
* $EEG135/XXYY IS THE FIRST RECORD ,XX IS THE FILE NUMBER AND  YY IS THE
* NUMBER OF THE RECORDS TO BE MODIFIED , RECORD-POSITIONS ARE MENTIONED
* AT THE END OF THE RECORD IN AN ASCENDING ORDER FROM RIGHT TO LEFT.
* IF NUMBER OF THE RECORDS IS MORE THAN 14,ORADDITIONAL RECORDS ARE TO B
* MODIFIED , NEXT RECORD STARTS WITH
* =YY  ,  =INDICATES CONTINUATION,YY IS THE NUMBER OF THE RECORDS
****************************************************************************
START RCTY
      BC3 *+36
      WATYMES1
      B   *+24
      WATYMES9
      RCTY
      H
      REW0
      REW2
      TF  READIN+160,RCMK
WTM   BC3 MODFST,,,DATA CORRECTION ....
      WTM2
      BNWC*+36
      ERF
      B   WTM
      TF  JBP+160,RCMK
TMK   RNT READIN-1
      BNPC*+24
      BTM RDCK,*+12
      BNV ERR8,,,FIRST TM IS MISSING.
      TOI0
      BKS0
NEXT  CM  PGN,0,10
      BE  NEXT1
      SM  PGN,1,10
      TDM TMEND+13,9
      TDM TEST+13,9
      B   REDT
```

```
NEXT1  TDM TMFND+13,1
       TDM TEST+13,1
*      TFM TMCK,0,10
       TFM ADDR,EDR
       BC1 COPI,,,SS1 ON IMPLIES NO EDIT
SS2    BC2 EDTINF,,,SS2 ON IMPLIES THAT JOB NO. IS SPECIFIED.
       B   REDT
* JOB NO. IS SPECIFIED ON THE TYPE WRITER.
EDTINFWATYJOBNO.
       RCTY
       RATYJBR
       TDM SS2+1,1
* READ OLD RECORD IN 'READIN'
       NOP
REDT   RNTOREADIN-1
       BNPCTEST
       BTM RDCK,TEST
TEST   BV  SURE
       NOP REDT
       NOP EDIT
INCR   TDM TEST+13,9
       SF  READIN+149
       C   READIN+156,EDITR+6
       BE  EDIN
       BNC2SEQ
EQUAL  SF  READIN-1
       SF  JBR-1
       C   JBR+16,READIN+16
THRO   BE  REDT
       AM  PRN,1,10
       TFM TMCK,0,10
       B   REDT
EDIN   AM  PRN,1,10
       TFM TMCK,0,10
       B   REDT
EC     RNTOREADIN-1
       BNPC*+24
       BTM RDCK,*+12
       BV  ERR2
JSRCH  SF  READIN-1
* SEARCH FOR THE SAME JOB NO. IN EDIT INFO.
       C   READIN+16,JBR+16
BR     BNE ERR3
       TR  EDR-1,READIN-
       TFM RD+18,EDR-1
RD     AM  RD+18,162,27
       RNTO**
       BNPC*+48
       TF  R+6,RD+18
```

```
       BTM RDCK,*+12
       TFM R+6,READIN-1
       BV  EDOVR,,,EDIT OVER
       TF  IA,RD+18
       SM  IA,1,7
       TF  IA,RCMK,6
       B   RD
SURE   BKSO
       RNTOREADIN-1
       BNRC*+24
       BTM RDCK,*+12
       BNV TEST+12
TMFND  TOIO
       NOP NEXT
       BTM SRCHTM,*+12
       AM  TMCK,1,10
       CM  TMCK,1,10
EDSRCHBH   EC
       TDM TEST+13,1
       B   REDT
* EDIT OVER
EDOVR  TOIO
       NOP *+48
       BKSO
       TDM EDOVR+13,9
       B   RD+12
       TDM EDOVR+13,1
       TFM EDR,ADDR
       TDM TEST+25,9
       TFM TMCK,1,10
       TF  PGN,PRN
       REWO
       B   NEXT
RDCK   BKSO
R      RNTOREADIN-1
       BNRCGOBACK
       AM  L1+11,1,10
L1     CM  NMAX,,10
       BE  ERR1
       B   RDCK
GOBACKTFM L1+11,0,10
       B   RDCK-1,,6
WRCK   BKS2
W      DNT2READIN-1
       BNWCWRCK-1,,6
       AM  *+9,10,10
       BNV WRCK
       BKS2
```

```
ERF2
B    W
TR   JBR-1,READIN-1
B    REDT
SF   READIN+151
SF   EDR+157
CM   EDR+158,70,10
BE   ALT
CM   EDR+158,71,10
BNE  ERR4,,,WRONG EDIT INFORMATION
ANS  THAT EDIT-INFOMATION IS GIVEN.
BTM  ZFIL,*+12
TFM  ALT+1,41,10
TFM  ADDR,EDR+158,7
AM   ADDR,6,7
TNS  ADDR,FNC,6
AM   ADDR,4,7
TNS  ADDR,CARDS,6
AM   ADDR,152,7
TNS  ADDR,N1,26
RNTOREADIN-1
BNRC*+24
BTM  RDCK,*+12
BV   PRGOV
BTM  ZFIL,COPY
TNS  READIN+158,JN
C    JN,N1
BL   ZFILO
BH   ERR4,,,WRONG EDIT INFORMATION
CM   FNC,99,10,TEST FOR END OF EDIT
BE   EDTOVR
CM   FNC,10,10,N1 IS IN STORE.
BE   DELETE
CM   FNC,15,10
BE   MODIFY
CM   FNC,05,10
BE   ADD
CM   FNC,0,10
BE   COPY
B    ERR4,,, WRONG EDIT INFORMATION
TFM  ALT+1,17,10
B    ALT
RNTOREADIN-1
BNRC*+24
BTM  RDCK,*+12
BV   OVF
BNC2ALT
WATYJOBNO.
```

```
FILL BLANKS IN THE . LAST FOUR COLS. AND WRITE ON THE TAPE
ZFIL  TR  READIN+151,ZERO
NEWRECDNT2READIN-1
      BNWC*+24
      BTM WRCK,*+12

      RCTY
      RATYJBR
      TFM THRO+6,ALT
      B   EQUAL
ZFILO BTM ZFIL,COPY
OVF   TOIO
      B   COPI
* FILL BLANKS IN THE LAST FOUR COLS. AND WRITE ON THE TAPE
ZFIL  TR  READIN+151,ZERO
NEWRECDNT2READIN-1
      BNWC*+24
      BTM WRCK,*+12
      B   ZFIL-1,,6
PRGOV TOIO
      TFM ADDR,EDR
      TDM TEST+25,1
      TDM SS2+1,6
*     TFM ALT+1,17,10
      TFM THRO+6,REDT
      RCTY
NEWTM WTM2
      BNWC*+72
      BKS2
      AM  *+9,10,810
      BNV NEWTM
      ERF2
      B   NEWTM
      BC2 OVER
      AM  PRN,1,10
      TF  PGN,PRN
      BTM SRCHTM,*+12
      REWO
      B   NEXT
SRCHTMRNTOREADIN-1
      BNRC*+24
      BTM RDCK,*+12
      BV  OVER
      BKSO
      B   SRCHTM-1,,6
* ADD NEW RECORDS AFTER N1
ADD   BTM ZFIL,*+12
      CM  CARDS,0,10
      BE  REST
      SM  CARDS,1,10
      BTM NXTREC,ADD
*   MODIFY A RECORD(N1)
MODIFYBTM NXTREC,*+12
      BTM ZFIL,REST
```

```
*  DELETE SOME RECORDS NUMBERRED AS N1 , N2 , N3 , .....
DELETECM  CARDS,1,10
       BE   BACK
       TF   IA,ADDR
       SM   IA,8
       TNS  IA,N1,6
       SM   CARDS,1,10
       TFM  DELETE+25,41,10
       B    COPY
BACK   TFM  DELETE+25,26,10
       B    REST
NXTRECAM  ADDR,3,7
       TR   READIN-1,ADDR,711
       AM   ADDR,159,7
       B    NXTREC-1,,6
*
*
ERR1   WATYMES2
       REWO
       REW2
       TFM  RDCK+35,0,10
       B    OVER+12
ERR2   WATYJBR
       WATYMES3
       RCTY
       TOIO
       REWO
       RATYREADIN
       SF   READIN-1
       CM   READIN,43,10
       BE   COPI
       CM   READIN,62,10
       BNE  ERR4
ERR3   TDM  TEST+13,9
       B    REDT
ERR4   WATYMES5
       B    OVER+12
ERR8   WATYMES8
       B    OVER+12
OVER   WATYMES7
       RCTY
       TFM  TMCK,0,10
       TDM  SS2+1,6
       TFM  PGN,0,10
       TFM  PRN,1,10
       H
*
*
```

```
        TF   JBR+22,RCMK
        TFM  TEST+30,MEDIT
        TFM  COUNT+6;EDR+158
DATA    TDM  TEST+13,9
        TFM  TMCK,0,10
        B    REDT
MEDIT   SF   EDR+1
        SF   READIN-1
        C    EDR+18,READIN+16
        BNE  DATA
MODFSTTDM  TEST+25,9
        TDM  TEST+13,1
        TDM  TWOTM+1,1
        TFM  CARDS,0,10
        TFM  MODF-1,STOR
        TFM  PRN,0,10
        NOP
        TFM  SRCHTM+42,REWIND
MODF    RNT2READIN-1
        BNRCOVFCK
        BTM  RDCK2,*+12
OVFCK   BNV  MODF-1,,6
        BKS2
        RNT2READIN-1
        BNRC*+24
        BTM  RDCK2,*+12
        BNV  MODF-1,,6
        TOI2
TWOTM   NOP  OVERCK
        TDM  *-11,9
        B    MODF
RDCK2   BKS2
        RNT2READIN-1
        BNRCCOME
        AM   L2+11,1,10
L2      CM   NMAX,,10
        BE   ERR1
        B    RDCK2
COME    TFM  L2+11,0,10
        B    RDCK2-1,,6
STOR    TR   EDR-1,READIN-1
        SF   EDR-1
        CM   EDR,13,10,$ SIGN
        BNE  CONTIN
**    $ SIGN IS OBTAINED
        CM   CARDS,0,10
        BNE  ERR10
        TR   JBR-1,READIN+1
```

```
       BNE *+10,42
ERR10  WATYMES10,,,INADEQUATE DATA.
       WATYJBR
       RCTY
       TNF MES12+2,CARDS
       WATYMES12
       RCTY
       B   ORIGIN
OVERCKCM   CARDS,0,10
       TNS EDR+22,CARDS
       TFM JN,0,8
       TFM TEST+30,A
COUNT  TNS **,N1
       SM  *-6,8
A      AM  JN,1,8
       C   JN,N1
       BNH REDT
       TF  JN,N1
*
*
       BTM MODF,*+12
       BTM CHECK,*+12
*
*
DN     BKSO
       DNTOREADIN-1
       BNWCON
       AM  *+9,10,10
       BNV DN
       B   ERR1
ON     SM  CARDS,1,10
       CM  CARDS,0,10
       BNE COUNT
       BTM MODF,STOR
*  = SIGN(CONTINUATION) IS OBTAINED.
CONTINCM   EDR,33,10,=SIGN FOR CONTINUATION
       BE  MOVE
       WATYMES13
       WATYJBR
       RCTY
       B   MODF,,,EXTRA RECORDS
MOVE   TNS EDR+4,CARDS
       TFM COUNT+6,EDR+158
       B   COUNT
CHECK  SF  READIN-1
       CM  READIN,13,10
       BE  ERR10
       CM  READIN,33,10
```

```
        BE   OVER
        B    ERR10
REWINDREWO
        TFM  TMCK,0,10
        TDM  TWOTM+1,1
        AM   PRN,1,10
        CM   PRN,2,10
        BNE  REDT
        TFM  Z+6,EDR+2
Z       CF
        AM   Z+6,1,7
        CM   Z+6,EDR+18
        BNH  Z
        TF   MES11+16,EDR+18
        WATYMES11
        RCTY
ORIGINTFM PGN,0,10
        TFM  PRN,1,10
        TFM  SRCHTM+42,OVER
        TFM  TEST+30,EDIT
        TFM  JN,0,8
        H
*
*
MES1    DAC  50,MOUNT OLD PROGRAM ON T0 AND EDITED PROGRAM ON T2.'
MES2    DAC  13,TAPE IS BAD.'
MES3    DAC  47, NO EDIT INFO. TYPE  C FOR COPY ,  S FOR SKIP.'
MES4    DAC  28,EDIT NOT AFTER THE PROGRAM.'
MES5    DAC  17,WRONG EDIT INFO.'
MES6    DAC  25,RECORD IS NOT AVAILABLE.'
MES7    DAC  7,$OVER$'
MES8    DAC  21,FIRST TM IS MISSING.'
MES9    DAC  45,MOUNT FILES ON T0 AND MODIFYING INFO. ON T2.'
MES10   DAC  20,INADEQUATE DATA IN '
MES11   DAC  24,                IS NOT ON T0.'
MES12   DAC  26,    MORE RECORDS REQUIRED.'
MES13   DAC  18,EXTRA RECORDS IN '
EDITR   DAC  4,EDIT
JOBNO.DAC    18,TYPE THE FILE NO.'
TMCK    DC   2,0
PRN     DC   2,01,,PROGRAM-NO.
PGN     DC   2,0
EDR     DS   ,20021,,EDIT INFO.
JN      DC   4,0
N1      DC   4,0
FNC     DC   2,0
CARDS   DC   2,0
NMAX    DC   2,50,
```

```
ADDR   DS  5
IA     DS  5
JBR    DAS 40
       DS  40
       DS  42
READINDAS 40,19841
       DS  40
       DS  42
ZERO   DSC 8,0
RCMK   DAC 1,'
       DENDSTART
```

1

```
*
*          FILE- VERIFICATION
*
******************************************************************
*READ RECORDS FIRST FROM TAPE0 THEN FROM TAPE2 , SEARCH FOR THE RE
* COMPARE THESE RECORDS. UNLIKE RECORDS ARE PUNCHED IN THE SEQUENCE-
* FIRST RECORD FROM TAPE0,SECOND FROM TAPE2
* VERIFICATION IS OVER WHEN THERE ARE TWO TAPE MARKS AFTER ANY PROGR
* ANY TAPE WHICH IS SPECIFIED IN THE MESSAGE.
* KEEP SS4 ON FOR PRINT OUTPUT
* TAPE0/TAPE2
* T(N) / R(N-1) -- TMCK( CHECK TAPE-MARK ON T2 )
* T(N)1/ T(N)1 --  ENDCK( CHECK FOR THE END OF THE FILE )
* T(N)2/ T(N)1  -- END2( FILES IN EXCESS ON T2 )
* T(N)1/ T(N)2  -- END0( FILES IN EXCESS ON T0 )
* R(N) / R(N) --- COMPARE
* R(1) / R(1)   -  STORE JOB-IDENTIFICATION
BEGIN REW0
      REW2
      TDM OVF+13,1
      TDM ER+1,1
      TR  MARK-1,BLANK
      TD  19999,00400
      NOP
IN1   RNT0LOC1-1
      BNFCOVF
      TFM RT+6,LOC1-1
      TDM RDCK+9,0
      TDM RT+9,0
      BTM RDCK,*+12
OVF   BV  TM0
      NOP ERR2,,0
IN2   RNT2LOC2-1
      BNFC*+60
      TDM RDCK+9,2
      TFM RT+6,LOC2-1
      TDM RT+9,2
      BTM RDCK,*+12
      BV  TM2
ER    NOP ,,0
      TR  COLMNS-1,BLANK
      TFM SFLAG+6,LOC1-1
      TFM SFLAG+18,LOC2-1
      TFM CFLAG+6,LOC1
      TFM CFLAG+18,LOC2
      TFM COLNO.,1,10
      TFM ACLM,2,9
      TFM MATCH,0,10
      AM  RCNO.,1,8
      TFM NFILL+6,COLMNS+30
      TR  MARK-1,BLANK
```

```
       TFM  STAR,MARK
SFLAG  SF   **
       SF   **
CFLAG  CF   **
       CF   **
COMP   C    CFLAG+6,CFLAG+18,611
       BE   INCR
NFILL  TNF  **,COLNO.
       CM   MATCH,17,10
       BE   SKIP
       TFM  STAR,13,610
       AM   NFILL+6,8,7
       AM   MATCH,1,10
INCR   CM   ACLM,160,9
       BE   OUT
       AM   SFLAG+6,2,7
       AM   SFLAG+18,2,7
       AM   CFLAG+6,2,7
       AM   CFLAG+18,2,7
       AM   COLNO.,1,10
       AM   ACLM,2,9
       AM   STAR,2,7
       B    SFLAG
OUT    CM   MATCH,0,10
       BE   IN1
       CM   MATCH,4,10
       BH   SKIP
PUT    TF   COLMNS+22,COL.+12
       TNF  COLMNS+6,RCNO.
       BNC4*+36
       WACDCOLMNS
*
       B    WBOTH
       WATYCOLMNS
       RCTY
*
       B    WBOTH
EARLY  TFM  SKIP+1,26,10
SKIP   TF   DUMMY,RCNO.
       TFM  SKIP+1,41,10
       C    DUMMY,RCNO.
       BE   PUT
       AM   DUMMY,1,8
       C    DUMMY,RCNO.
       BL   EARLY
ERR3   BC4  *+48
       WATYMES3
       RCTY
       B    PASSO
```

```
        REW2
        TFM ER-1,TM2
        WATYMES2
        WATYT
        B    STOP+12
 END2   TFM ER-6,STOP
        BTM IN2,*+12
        TDM T,2
        B    FINISH
 STOP   TFM ER-6,TM2
        RCTY
        WATYOVER
        BNC4*+10,48
        WACDBLANK+3
        WACDBLANK+3
        WACDBLANK+1
        H
*
*
MES1    DAC 13,TAPE IS BAD.'
MES2    DAC 25, FILES IN EXCESS ON TAPE'
T       DAC 3,0.'
MES3    DAC 24,HEAVY MISMATCH ONWARDS.'
OVER    DAC 7,$OVER$'
MATCH   DC  2,0
ACLM    DC  3,2
RCNO.   DC  4,0
DUMMY   DC  4,0
STAR    DS  5
NMAX    DC  2,10
COLNO.  DC  2,0
COL.    DAC 8,COLUMN-'
MARK    DAS 40
        DAS 40
        DAC 1,'
BLANK   DSC 40,0
        DSC 40,0
        DSC 40,0
        DSC 41,0
        DC  1,'
LOC1    DAS 40
        DS  40
        DS  40
        DAC 1,'
LOC2    DAS 40
        DS  40
        DS  40
RCMK    DAC 1,'
COLMNSDAS 40
        DAS 40
        DAC 1,'
        DENDBEGIN
```

```
     *
******    FILES  ON  TAPE 0
     *
     ******************************************************************
     *       TAPE-MARK
     ******************************************************************
EEG135/01
      FIRST RECORD           ON TO
         SECOND RECORD IS COMMON
      THIRD RECORD IS IN EXCESS
     ******************************************************************
     *       TAPE-MARK
     ******************************************************************
EEG135/02
      II  FILE -   FIRST RECORD
      2.   SECOND RECORD       123.45     132.45    23 .85   123.65              123.65850
     GOOD-BYE    12345,45213,784521,963,452135,7854,3251,4563,785,45632,453.85,36
123456589 7,7558642588 52,78541236.2145,78546321.653254,7 426339.325,4521330254.55
4521.78452     854.7854       5652.7985      7542.5241       7895.788      5862.420
     ******************************************************************
     *       TAPE-MARK
     ******************************************************************
EEG135/05
   I THANK YOU VERY MUCH
PLEASE STOP IT.
      END OF TESTING , GOOD-BYE.        1
```

```
      *
******    FILES  ON  TAPE 2
      *
      ***********************************************************************
      *       TAPE-MARK
      ***********************************************************************
EEG135/01
       FIRST RECORD          ON T2
          SECOND RECORD IS COMMON
      ***********************************************************************
      *       TAPE-MARK
      ***********************************************************************
EEG135/02
       II  FILE -   FIRST RECORD
       2.   SECOND RECORD      123.40      122.45     235.85   123.65              123.65850
      GOOD-BYE   12345,45255,784521,563,452135,7854,3251,4563,785,45632,483.85,38
1234558924558842582558785412358.2145,71234521.653254,78756339.325,4521330284.55
4521    45635     865.452    785.520785     9556.3247    79552335б       485.35225
      ***********************************************************************
      *       TAPE-MARK
      ***********************************************************************
EEG135/05
   I THANK YOU VERY MUCH                  5
PLEASE STOP IT.            MY DEAR SIR.
       END OF TESTING , GOOD-BYE.
```